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PALEONTOLOGY.—*New genera of Foraminifera from the British Lower Carboniferous.*

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As part of a study of the British Carboniferous Foraminifera a revision of the Brady collection of Carboniferous and Permian Foraminifera in the British Museum (Natural History) has been completed. One of the most important results has been the recognition of new genera and species that not only are of stratigraphical value but also assist in the interpretation of the morphogeny and phylogeny of the Upper Paleozoic Foraminifera. Since some aspects of the major study are incomplete as yet and in order that the information on the new genera may be made available to other workers, a detailed description of three new genera and their type species are given here.

It is interesting to note that no closely similar forms have been recorded from the American Mississippian, and it is hoped that this publication will lead others to confirm their presence or absence in extra-British areas.

The writer would like to acknowledge the continued support of Prof. Neville George in this research and the valued cooperation and assistance from Dr. Alfred R. Loeblich, Jr., Dr. Helen Tappan, and other American experts and friends.

Family ENDOTHYRIDAE

Subfamily BRADYININAE

ENDOTHYRANOPSIS, n. gen.

Involutina (*pars*) Brady, 1869 (*non* Terquem, 1862).
Endothyra (pars) Brady, 1873, 1876, *et auctores*.

Type species (here designated): *Involutina crassa* Brady, 1869.

Description.—Test free, relatively large, subglobular to nautiloid; coiled with a slight degree of axial rotation and hence somewhat asymmetrical; relatively few whorls and moderate number of crescentiform chambers; almost or entirely involute with simple, slight sutures and rounded peripheral margin; granular surface; wall of granules of calcite bound by calcareous cement with small but varying proportion of adventitious material; apertural face inflated with low, lunate opening at base.

Comparison and affinities.—The genus *Endothyranopsis* differs from members of the Endothyrinae in several features. In the latter the wall is composed solely of granules of calcite bound by calcareous cement and is imperforate whilst, in the case of the new genus, the wall is not only relatively thicker and typically perforate but has a varying subordinate quantity of adventitious material, usually in the form of quartz-grains and iron oxides. Other and more minor differences are to be found in the mode of coiling, number and form of chambers, and possibly in septal construction.

The inclusion of *Endothyranopsis* within the Bradyininae is based on obvious similarities of wall-structure and form to other members of the subfamily. Morphologically the simplest and stratigraphically the oldest, *Endothyranopsis* appears to occupy a near ancestral position within the group and may represent an early development toward *Bradyina* Möller and *Cribrospira* Möller from the agglutinate ancestral stock.

In the thin-sections of sagittal type, *Endothyranopsis* may be recognized by the relatively thick wall of characteristic composition, the few whorls and moderate number of chambers, the ploughsharelike or ax-shaped septal outlines, and the slight irregularity of coiling (Fig. 1, A). In transverse section it is often difficult to distinguish from other members of the Bradyininae, for the strong obliquity of septal curvature in

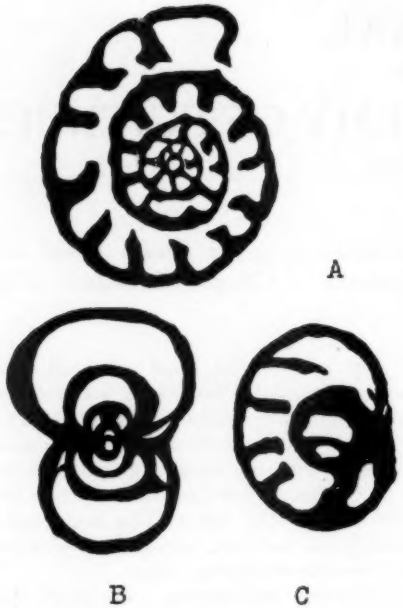


FIG. 1.—*Endothyranopsis* sp. Diagrams based on actual specimens showing typical appearance in thin-section: A, sagittal section; B, transverse section showing apparent lateral chamberlets due to septal curvature and axial rotation; C, oblique excentric tangential section. All × 35.

Endothyranopsis may produce apparent lateral chamberlets in the umbilical region (Fig. 1, B) that appear identical to the sutural chamberlets of *Bradyina* when seen in the same section. However, other morphological differences, such as the presence of axial rotation of coiling in *Endothyranopsis* in contrast to the planispiral coiling of *Bradyina*, allow a distinction to be made in most cases.

Preservation and matrix.—While the true nature of the wall structure is clearly demonstrable in well-preserved material, the large number of specimens that have undergone secondary alteration during the diagenesis of the host sediment have led to confusion in the past. The perforate nature of the wall was noted by Möller (1878, p. 94), and though examples have been found in British material these are few in number. It would appear that one of the first stages in the alteration of the wall leads to the recrystallization of the calcareous matrix within the perforations and the production of granular calcite of similar texture of that of the primary wall. Hence an apparently uniform development of calcite results that is superficially identical to that of the primary wall structure of the Endothyrinae.

Quartz grains and fragments of several oxides of iron are the dominant types of adventitious material, and it may be that the nature of the environment determines the choice. Thus iron oxides are rather common in specimens from a host rock with a high iron content. Such evidence is by no means conclusive, however, for the factor of secondary iron enrichment in both sediment and specimen must not be overlooked.

The distinction between quartz-grains of the primary wall-structure and crystalline quartz introduced by partial silicification during diagenesis is difficult and is possible only after study of both specimen and host sediment. Rarely perfect steinkerns of silica are produced (Fig. 5, C) which are valuable in the analysis of internal morphology.

Horizon and facies.—*Endothyranopsis* is a common and characteristic genus occurring in a wide variety of limestone and calcareous shale environments in the upper part of the British Lower Carboniferous. It has been recorded, as *Endothyra crassa* Brady, at similar horizons in Belgium, central Europe, and the U.S.S.R.

In addition to the type species the following may be referred to *Endothyranopsis: Endothyra conspicua* Howchin, 1888; *Endothyra crassa* var. *compressa* Rauser-Chernoussova and Reitlinger, 1936; and *Endothyra crassa* var. *sphaerica* Rauser-Chernoussova and Reitlinger, 1936.

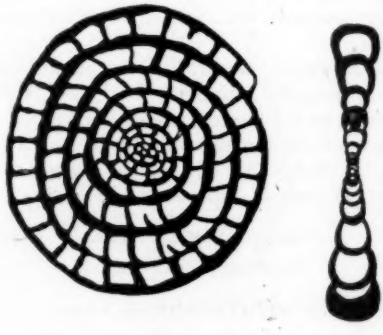


FIG. 2.—*Loeblichia* sp. Diagrams based on actual specimens showing typical appearance in thin-section: A, sagittal section slightly excentric with variation in wall thickness due to distortion of specimen; B, axial section showing position of septa in some whorls. Both × 75.

Endothyranopsis crassus (Brady)

Fig. 5, A–C

Involutina crassa (*pars*) Brady, 1869.
Endothyra crassa (*pars*) Brady, 1876, *et auctores*.

Description.—Test free, relatively large, nautiloid, subglobular, slightly asymmetrical; some degree of axial rotation of coiling resulting in rather small, shallow umbilical depression on one side and involute condition on other; usually three whorls present, increasing moderately in height as added and almost complete embracement throughout; proloculum varies from 0.02 to 0.05 mm in diameter; 28 to 35 chambers in complete test and 10 in final whorl; chambers crescentiform with maximum width on median plane and tapering toward umbilical regions, having squarish outline in median section and with no marked inflation; somewhat inconspicuous slightly depressed sutures, crenulated in parts and losing identity toward umbilici; radially aligned septa varying in shape from periphery to umbilici having a maximum thickness about one-third that of adjacent chambers; septal tunnel some one-third height of adjacent chambers; peripheral margin broadly and smoothly rounded with faint lobulation; surface rugose or granular; wall of granules of calcite bound by calcareous cement with a varying amount of adventitious material, usually quartz grains and more rarely oxides of iron, perforate in an irregular manner; apertural face broad, convex, slightly inflated shield with low, lunate opening at base on periphery.

Depository, etc.—Lectotype (slide P. 41651) and paratypes (slide P. 35439) in the Brady collection of Carboniferous and Permian Foraminifera, British Museum (Natural History), from the upper part of the Lower Carboniferous, Great Orme's Head, Caernarvonshire, North Wales (ex Dr. Holl's collection) (Brady locality no. 36).

Dimensions.—Lectotype: maximum diameter 1.41 mm; minimum diameter 1.29 mm; maximum width 0.91 mm; width of apertural face 1.1 mm; height of apertural face 0.5 mm.

Comparison and affinities.—The species, as redefined here on the basis of the type material, differs markedly from other forms in the British Lower Carboniferous as yet undescribed and hitherto included by previous authors in *Endothyra crassa* Brady. It differs from *Endothyranopsis conspicuus* (Howchin) in having a lower degree of axial rotation of coiling, a broader cross section and more tapering chambers.

Preservation and matrix.—Brady (1876, p. 97) notes the presence of small tubercles in the umbilical regions of *Endothyranopsis crassus* but these appear to be remnants of the original matrix in the type material (Fig. 5, A) and products of secondary alteration in other instances. Probably owing to a thinner wall the last chamber of the species is most commonly broken away. This is so in the case of the figured lectotype (Fig. 5, B), also figured by Brady (1876, pl. 5, fig. 16).

Horizon and facies.—*Endothyranopsis crassus* (Brady) is confined to the lower part of the Lower Limestone group in the Scottish Lower Carboniferous, being very common in the Dockra limestone and other contemporaneous limestones in the west of the Midland Valley and in the No. 2 limestone in the east. It occurs in the lower part of the Upper *Dibunophyllum* zone in the English Avonian. Earlier records of *Endothyra crassa* Brady occurring outside this stratigraphical range are based on specimens referable to the genus *Endothyranopsis* but not to the type species, *Endothyranopsis crassus* (Brady).

LOEBLICHINAE, n. subfam.

Tests characterized by small size, planispiral or subplanispiral mode of coiling and evolute condition, short axis of rotation, numerous whorls and chambers, wall of unknown primary composition and structure, aperture of indistinct nature and usually terminal.

This subfamily includes the new genus *Loeblichia* and is probably related to the Ozawainellinae. Reasons for the recognition of this new taxonomic unit are outlined below.

LOEBLICHIA, n. gen.

Endothyra (*pars*) Brady, 1873, 1876, *et auctores*.

Type species (here designated): *Endothyra ammonoides* Brady, 1873.

Description.—Test free, relatively small, discoidal or complanate; numerous whorls coiled in a planispiral manner though axial rotation may occur in early or late stages of growth; chambers numerous, crescentiform, regularly arranged, square to rectangular in sagittal section; sutures distinct and depressed in later portion only and internal septa normal to peripheral margin in sagittal section; periphery usually slightly lobulate; primary structure of wall unknown—

usually preserved in recrystallized calcite, amorphous or crystalline silica; no chomata or secondary deposits present; aperture terminal, lunate opening at base of apertural face.

Comparison and affinities.—The genus *Loeblichia* does not appear to be related to any of the contemporary Endothyrinae of the Lower Carboniferous. It differs from *Endothyra* Brown, 1843, *Endothyra* Phillips, 1846, *Plectogyra* Zeller, 1950, and *Millerella* Thompson, 1942, in the structure of the wall, the manner of coiling, and the chamberal arrangement.

Certain morphological similarities exist between *Loeblichia* and *Nanicella* Henbest, 1935, originally described from the Devonian of Iowa by Thomas (1931). It is doubtful, however, whether the degree of isomorphism is sufficient to indicate a common ancestry. Indeed the contrasting dissimilarities in number of chambers, number of whorls, rate of chamberal growth, septal form and alignment suggest an analogous rather than homologous relationship between the two genera. The same conclusions can be made in a comparison of *Loeblichia* and *Rhenothyra* Beckmann, 1950, from the Rhenish Devonian where the morphological differences are even greater.

Though *Loeblichia* might be considered an aberrant specialization of the Endothyrinae, as is the case of *Paraendothyra* Tchernysheva, 1940, both the stratigraphical and morphological evidence tells against its inclusion, and hence it is classified separately within the Loeblichinae. This may prove to be the ancestral stock from which such problematical fusulinids as *Ozawainella* Thompson, 1935, *Nankinella* Lee, 1933, and *Nummulostegina* Schubert, 907, arose.

In sagittal section *Loeblichia* is distinguished by the characteristically altered wall structure, the numerous whorls and chambers, the normality of septal alignment to the peripheral margin, and septal form (Fig. 2, A). In transverse section the planispiral coiling, wall-structure, septal intersections, mode of chamberal growth, and absence of chomata are criteria for its distinction from both representatives of the Endothyrinae and the Ammodiscidae.

Preservation and matrix.—Brady (1876, p. 95) notes that the test-wall of the type material of *Endothyra ammonoides* has a "compact arenaceous texture" in thin-section, and Wood (1949, p. 239), describing the same material, writes: "When the tests are certainly recrystallized (as for instance in the specimens of *E. ammonoides* figured by Brady 1876, pl. V, fig. 6) the grain size is much greater, and the specimen is *less* dark in transmitted light than the infilling." These descriptions are inadequate, for they fail to reveal that all specimens from the type locality are secondarily silicified and that the test-wall is composed of either amorphous or crystalline silica. Examples of the latter show "a compact arenaceous texture," and, should this be associated with an internal matrix of recrystallized calcite, as is often the case, the optical properties noted by Wood would be illustrated.

Numerous specimens of *Loeblichia* have been examined from both English and Scottish areas, and in every case the microstructure of the wall has been altered from its primary condition.

Often silicification of the host sediment has led—as in the case of the type material—to the production of crystalline quartz of irregular and comparatively large grain size which might be misinterpreted as a primary arenaceous agglutinate structure. The production of amorphous silica could be mistakenly identified as an original siliceous structure if no reference was made to the diagenesis of the host sediment. In certain Ayrshire localities replacement of the test-wall by cryptocrystalline silica of the chalcedonic variety has produced, by its fibrous structure, a superficial similarity to the hyaline perforate condition.

The usual mode of preservation is in secondarily recrystallized calcite though examples are known where the wall is formed by an irregular dolomitic growth. Alteration of the calcareous structure is illustrated by the absence of cement, the irregularity and relatively large size of the constituent particles and the arrangement of the particles in relation to septal form (Fig. 3).

Except in a few cases the products of alteration differ in the test-wall and the matrix, indicating a difference in original composition or physical structure or both between the test and the host sediment.

This proneness to alteration in *Loeblichia*, seen in numerous specimens from a variety of limestone and calcareous shale environments, is in direct contrast to the resistance to alteration shown by the Lower Carboniferous Endothyrinae, e.g., in *Endothyra*, *Plectogyra*, or *Millerella*. While examples of alteration are not unknown and are not uncommon in some areas, owing to local diagenetic phenomena, the permanence of

microstructure in the Endothyrinae is demonstrable in several ways; by the regularity of fine grain size in wall texture over wide areas and in a variety of facies, or again, by the maintenance of layering within the wall to the same proportions in each particular group. Many examples have been noted where altered specimens of *Loeblichia* occur, in the same sample, alongside unaltered members of the Endothyrinae. Hence the wall-structure of *Loeblichia*, in its original condition, must differ fundamentally from that of the Endothyrinae. It is for this reason that the new genus is included in the Loeblichinae.

Horizon and facies.–*Loeblichia* is comparatively rare in the British Lower Carboniferous and is confined to the upper horizons. It has been recorded from the upper part of the Yoredale series in Northumberland, the Upper Dibunophyllum Zone of Northwest England, and both the Lower Limestone group and the Upper Limestone group of Scotland.

Loeblichia ammonoides (Brady)

Fig. 5, D, E

Endothyra ammonoides Brady, 1873, 1876, *et auctores*.

Description.—Test free, relatively small, laterally compressed, of a complanate or biconcave form; coiling planispiral throughout the greater part though some indication of axial rotation in the first half whorl after the proloculum and again toward the apertural region, where it leads to a slightly asymmetrical arrangement of the last four or five chambers; broad, shallow umbilici; whorls increase very slowly in height and embracement of one-quarter at any point; 10 whorls with numerous, small, slightly inflated, subcuboidal chambers in each, 23 in final whorl; in early part sutures thin, depressed lines, but in later portion depressed broad, possibly limbate, and with a sutural curvature away from the apertural region; septa about three-quarters height of whorl in length and one-quarter width of adjacent chambers in thickness; peripheral margin smoothly rounded and faintly lobulate outline; smooth or finely granular surface; wall of unknown primary composition—type material preserved in amorphous or crystalline silica; slightly inflated, terminal, shieldlike apertural face with low, lunate opening at base on median line with some indications of an original vestibular structure.

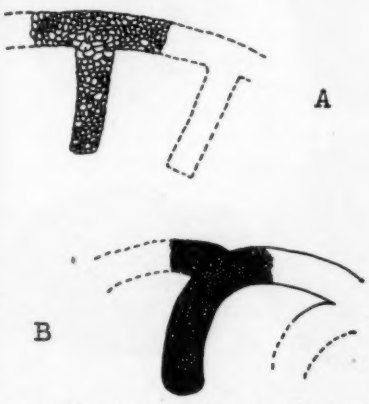


FIG. 3.—Diagrams of texture of wall structure illustrating the effect of alteration, based on actual specimens. A, In *Loeblichia* (recrystallized) showing the irregularity of grain size and pattern. B, In *Endothyra* (unaltered) showing regularity of grain size and pattern which leads to retention of original septal margin. Both × 400.

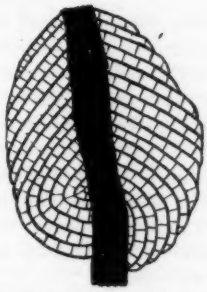


FIG. 4.—*Fourstonella* sp. Diagram based on actual specimen showing typical appearance in thin-section; longitudinal section of specimen attached to crinoid ossicles (black) showing inequality of septal and layer wall and differing size of chamberlets on either side of foreign body—latter feature due to obliquity of section on right side. × 60.

Depository, etc.—Lectotype (slide P. 41650) and paratypes (slide P. 35438 and section P. 35500) in the Brady collection of Carboniferous and Permian Foraminifera, British Museum (Natural History), from the upper part of the Lower Carboniferous, Keld Head Mines, Wensleydale, Yorkshire, England (Brady locality no. 29).

Dimensions.—Lectotype: maximum diameter 0.57 mm; minimum diameter 0.54 mm; maximum thickness 0.11 mm.

Comparison and affinities.—The species, as redefined here on the basis of the type material, differs from other and as yet undescribed forms of

Loeblichia, from the upper part of the British Lower Carboniferous, that hitherto have been grouped under *Endothyra ammonoides* Brady.

Preservation and matrix.—Vide supra.

Horizon and facies.—Loeblichia ammonoides (Brady) appears to be confined to the Lower Limestone group in the Scottish Lower Carboniferous and to equivalent horizons in England. Limited to a calcareous shale facies it has a spasmodic mode of occurrence and is never abundant or widespread.

Family TROCHAMMINIDAE

Subfamily TETRATAXINAE

FOURSTONELLA, n. gen.

Stacheia (*pars*) Brady, 1876, *et auctores*.

Type species (here designated): *Stacheia fusiformis* Brady, 1876.

Description.—Test attached, rarely free, small, fusiform, or globular; composed of series of layered chamberlets or subdivided segments arranged regularly around a foreign body such as crinoid ossicle, brachiopod spine, plant, etc.; layers subconical in form and concentric in arrangement, overlapping at margins, thin and numerous; chamberlets separated within layers by secondary septa which are thinner than walls of layers; often faint sutures concentrically arranged on exterior surface marking termination of laminae, otherwise smooth surface and peripheral outline; wall of calcareous granules bound by calcareous cement; aperture indistinct, terminal, basal, at margin of test and foreign body.

Comparison and affinities: Fourstonella and *Stacheia*, as typified by *Stacheia marginulinoides* Brady, 1876, are distinguished by the fusiform shape, regularity and pattern of layer arrangement, and unequal thickness of septal and layer wall of the former to the irregular or acervuline mode of growth and equality of septal and layer wall thickness of the latter.

Both *Fourstonella* and *Stacheia* appear to be independent derivatives of *Valvulinella* Schubert, 1907, which is undoubtedly developed from

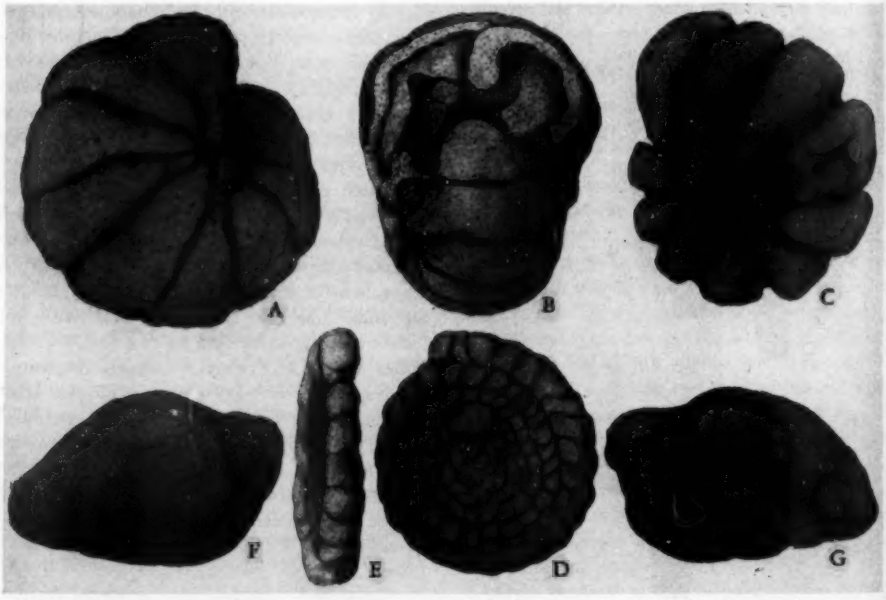


FIG. 5.—A, B (both × 35), *Endothyranopsis crassus* (Brady): A, Lateral view of lectotype (Brit. Mus. Nat. Hist. P. 41651) showing original matrix in umbilicus; B, Apertural view of lectotype showing broken final chamber. C (× 35), *Endothyranopsis* sp.: Steinkern in silica (Glas. Univ. Geol. Dept. Coll. P. 1000) showing internal morphology. D, E (× 75), *Loeblichia ammonoides* (Brady): D, Lateral view of paratype (Glas. Univ. Geol. Dept. Coll. P. 1002) showing side of specimen and adhesion of matrix in parts; E, Apertural view of paratype. F, G (× 65), *Fourstonella fusiformis* (Brady): F, Dorsal view of paratype (Glas. Univ. Geol. Dept. Coll. P. 1001); G, Ventral view of same specimen with position of original foreign body shown in form of test.

Tetrataxis Ehrenberg, 1843. This phylogenetic sequence from *Tetrataxis* is expressed morphogenetically by an increasing subdivision of chambers and irregularity of form and accompanies a transition to a fixed mode of life. *Stacheia* represents the culmination of this trend whilst *Fourstonella* expresses and represents an independent, partial fulfilment.

In thin-section *Fourstonella* is characterized by its fusiform or circular outline, sessile habit, granular calcareous wall-structure, and inequality of septal and layer wall thickness (Fig. 4).

Preservation and matrix.—With a few exceptions all specimens of *Fourstonella* appear to have undergone little or no alteration and the primary structure of the wall is retained. Where silicification by chalcedonic varieties has taken place in both *Fourstonella* and *Stachia* concentric rings may develop on the exterior surface which are similar to, but independent of, the sutural pattern of *Fourstonella*.

Horizon and facies.—Although confined to the upper part of the British Avonian—the upper part of the Dibunophyllum zone and its equivalents—*Fourstonella* is a common and characteristic form of shelly limestone and calcareous shale facies.

Fourstonella fusiformis (Brady)

Fig. 5, F, G

Stacheia fusiformis Brady, 1876, *et auctores.*

Description.—Test attached, short, stout, symmetrical, fusiform, round in cross-section, tapering at both ends, composed of layers of chamberlets—or subdivided segments—symmetrically arranged around thin, columnar, foreign body; each layer embracing previous one at peripheral margin; chambers thin, numerous, subdivided by secondary septa into minute chamberlets; external suture lines thin, concentric, depressed; transverse secondary septa thinner than chamber or layer wall; periphery smoothly rounded and smooth or faintly granular surface; wall homogeneous, of calcareous granules bound by calcareous cement; aperture indistinct, terminal, basal.

Depository, etc.—Lectotype (slide P.41654) and paratypes (slide P.35458 and section P.35509) in the Brady collection of Carboniferous and Permian Foraminifera, British Museum (Natural History), from the upper part of the Lower Carboniferous, Fourstones, Northumberland, England (ex Rev. W. Howchin's collection) (Brady locality no 16).

Dimensions.—Lectotype: maximum length 0.67 mm; maximum breadth 0.51 mm.

Comparison and affinities.—Brady (1876, p. 114) suggests that this form is closely allied to *Stacheia marginulinoides* Brady. However, when all morphological features are considered such a relationship is more apparent than real.

Preservation and matrix.—*Vide supra.*

Horizon and facies.—*Fourstonella fusiformis* (Brady) is present in the upper part of the British Lower Carboniferous in all areas and is particularly common in the shelly limestone facies.

REFERENCES

BECKMANN, H. *Rhenothyra, eine neue Foraminiferengattung aus dem rheinishen Mitteldevon.* Neues Jahrb. Geol. Pal. Monatshefte **6**: 183–187. 1950.

BRADY, H. B. *Notes on the Foraminifera of Mineral Veins and adjacent strata.* 39th Meeting (Exeter) Brit. Assoc. Adv. Sci.: 379–381 1869.

———. *Explanation of Sheet 23.* Mem. Geol. Surv. Scotland: 63, 95, etc. 1873.

———. *Monograph of Carboniferous and Permian Foraminifera (the genus* Fusulina *excepted)*: 1–166, Palaeontographical Soc. London, 1876.

BROWN, T. *The elements of fossil conchology.* London, 1843.

EHRENBERG, C. G. *Meloniae of the Oolitic limestones of Germany and England.* Ber. Preuss. Akad. Wiss. Berlin 1843: 106.

HENBEST, L. G. Nanicella, *a new genus of Devonian Foraminifera.* Journ. Washington Acad. Sci. **25**: 34–35. 1935.

HOWCHIN, W. *Additions to the knowledge of the Carboniferous Foraminifera.* Journ. Roy. Micr. Soc. 1888: 533–545.

LEE, J. S. *Taxonomic criteria of Fusulinidae with notes on seven new Permian genera.* Nat. Res. Inst. China Geol. Mem. **14**: 1–32. 1933.

MÖLLER, V. VON. *Die spiral-gewundenen Foraminiferen des russischen Kohlenkalkes.* Mem. Acad. Imp. Sci. St. Petersburg, ser. 7, **9**: 1–147. 1878.

PHILLIPS, J. *On the remains of microscopic animals in the rocks of Yorkshire.* Proc. Geol. and Poly. Soc. W. Riding Yorks. **2**: 274. 1849.

RAUSER-CHERNOUSSOVA, D. M., BELJAEV, G., AND REITLINGER, R. *The Upper Palaeozoic Foraminifera of Petschoraland (western margin of the northern Urals).* Trans. Polar Comm. Acad. Sci. U.S.S.R. **28**: 159–232. 1936.

SCHUBERT, H. J. *Vĕrlaufige Mitteilung über Foraminiferen und Kalkalgen aus dem dalmatinischen Karbon.* Verh. Geol. Reichs. Wien, Jahrg 1907: 211–214. 1907.

TCHERNYSHEVA, N. E. *"On the stratigraphy of the Lower Carboniferous Foraminifera in the*

Makarovski District of the southern Urals." Bull. Soc. Nat. Moscou **49**: sec. geol. 18: 113–135. 1940.

TERQUEM, O. *Recherches sur les foraminifères du Lias.* Mém. Acad. Imp. Metz 1862.

THOMAS, A. O. *Late Devonian Foraminifera from Iowa.* Journal. Pal. **3**: 40–41, 1931.

THOMPSON, M. L. *The fusulinid genus* Staffella *in America.* Journal. Pal. **9**: 111–120. 1935.

———. *New genera of Pennsylvanian fusulinids.* Amer. Journ. Sci. **240**: 403–420. 1942.

WOOD, A. *The structure of the wall of the test in the Foraminifera; its value in classification.* Quart. Journ. Geol. Soc. London **104**: 229–255. 1948.

ZELLER, E. *Stratigraphic significance of Mississippian endothyranoid Foraminifera.* Univ. Kansas Pal. Publ. art. 4, Protozoa, 1950.

PALEONTOLOGY.—*Foraminifera from some "Pliocene" rocks of Egypt.* RUSHDI SAID, Cairo University, Egypt. (Communicated by Alfred R. Loeblich, Jr.)

This paper lists some 40 species of Foraminifera separated from marly limestones of a supposedly "Pliocene" outcrop in Helwan, Egypt.

The "Pliocene" deposits in Egypt have been the subject of many discussions and the basis of an enormous amount of literature. The best description of them is found in Blanckenhorn (1903 and 1921) and in Picard (1943). The most authentic and complete résumé on the Pliocene of the Nile Valley, with which this paper is concerned, is found in Sandford and Arkell (1939).

The "Pliocene" deposits of the Nile Valley occur in the form of isolated outcrops that extend along the sides of the valley in a thin strip stretching from Cairo to the vicinity of Aswan. The outcrops occupy a more or less uniform height above sea level—indicating that a narrow arm of the Mediterranean Sea occupied the Nile Valley, and on the basis of stratigraphic relations and marine macrofossils during Astian time. There are two main facies, a marine facies of limestones and marly limestones along the immediate sides of the valley in the north and a conglomeritic sandy facies in the south and in the outer fringes of this ancient "Pliocene" gulf.

The outcrop from which the following species of Foraminifera come lies some 10 km south of Helwan, a village to the south of Cairo. Macrofossils found in the outcrop include some considered to be the most typical guide fossils for the Egyptian Pliocene, such as *Ostrea cucullata*, *Pecten benedictus*, and *Chlamys scabrellus*. The section consists of beds of marly limestones and limestones some 25 meters thick unconformably overlying Eocene rocks and overlain by a gravelly terrace ascribed by Sandford and Arkell to the Plio-Pleistocene.

This study shows many interesting conclusions with regard to the age of this formation and the origin of its fauna.

Age.—The Foraminifera recorded in the area are decidedly Mediterranean in aspect. They compare well with the Pliocene and Pleistocene faunas of the Mediterranean region and many species are still living today in the Mediterranean. Four species *Cibicides gibbosa*, *C. rhodiensis*, *Asterigerina rhodiensis*, and *Quinqueloculina foliacea* are known from the lower Pleistocene deposits of the Isle of Rhodes. Practically all other species are known and are typical of other such classical late Cenozoic localities of Italy and Spain. *Unicosiphonia cf. U. crenulata* is a characteristic fossil of the Pleistocene which is here recorded for the first time in the Mediterranean region.

There are some interesting points about the assemblage. The majority of the species are cold-water forms. In fact this assemblage, mainly composed of representatives of the families Textulariidae and Buliminidae, can well be compared with that living today in the deeper waters of the Recent Mediterranean (see for example the ecological studies of Colom (1942) and Said and Kamel (in press) on the Recent Mediterranean fauna). The presence of this deep-water fauna in the ancient shallow Nile Valley gulf can be interpreted only as indicating a cold climate in Egypt at the time of the deposition of this formation. The distribution of the detrital sandy facies in the gulf shows that the climate was also wet.

This type of cool wet climate compares well with the climate of the Calabrian

stage, now regarded on the basis of this kind of climate as belonging to the lower Pleistocene (Migliorini, 1948, and Movius, 1949).

This assemblage from Helwan includes many species that do not appear in the Pliocene-Pleistocene succession of the Rovigo boring, Italy (di Napoli-Alliata, 1946), except in the Calabrian. These species that seem to indicate the onset of the Calabrian stage are: *Textularia abbreviata*, *T. aciculata*, *T. sagittula*, and *Discorbis orbicularia*.

From these two interesting observations it would seem that the "Pliocene" outcrop of Helwan should be assigned to the Calabrian stage that opens the Pleistocene period. Such an assignment would have far reaching implications inasmuch as it would put the entire evolutionary history of the River Nile in the post lower Pleistocene time. A reevaluation and re-dating of the terraces left behind the Nile in pre-human times should therefore be investigated in the light of this new evidence.

Although this study has been restricted to the Helwan area, it is possible that all other outcrops of the Nile Valley described as Pliocene may also belong to the Calabrian stage since all can well be correlated on the basis of their fossil content and stratigraphical relations with those of Helwan. If such is the case the very presence of Pliocene marine deposits in Egypt is questionable. Work on the revision of the macrofauna of the so-called Pliocene of Egypt is now in progress.

Origin of the fauna.—There can be no doubt that the foraminiferal fauna described here is Mediterranean in aspect. However two facts remain to be noted. The complete absence of Indo-Pacific species in the assemblage is interesting inasmuch as it confirms the conclusions reached by Cox (1929), Picard (1943) and Sandford and Arkell (1939) as to the absence of any connection between the Mediterranean and the Red Sea since Miocene times. On the other hand, Said and Yallouze (in press) have shown recently from an analysis of the Miocene faunas of Gebel Oweibid, Egypt, that even though the fauna is overwhelmingly Mediterranean in aspect it also includes some elements of the Indo-Pacific region—a fact which points to a temporary ingression of the Indo-Pacific. The composition of the Helwan Calabrian foraminiferal fauna seems to show that this connection ceased entirely during the Pliocene and lower Pleistocene time—contrary to Ball's paleogeographic map (1939), which shows a connection between the Mediterranean and the Red Sea during the Pliocene.

The second fact to be noted is the presence of *Cibicides gibbosa* and *C. rhodiensis*, typical lower Pleistocene Mediterranean species in the Recent waters of the Red Sea. This can be explained only by assuming a temporary connection between the Mediterranean and the Red Sea in post lower Pleistocene time to allow for the migration of these species. Such a connection must have been very temporary, since it did not substantially affect the aspect of the faunas of both seas which remain distinct. This assumed connection is confirmed by the presence of a marine level in the clysmic area common to both the Mediterranean and the Red Sea (as described by Hume and Little, 1928) and dated as Midde Paleolithic.

Family TEXTULARIIDAE

Genus **Textularia** Defrance, 1824

Textularia abbreviata d'Orbigny

Textularia abbreviata d'Orbigny, Foram. Foss. Vienne: 249, pl. 15, figs. 9–12. 1849.

This distinct species occurs in small numbers in the samples from Helwan. This species has been noted from the Miocene of central Europe, but does not seem to appear in the Mediterranean until the Calabrian. It is also recorded from the Recent seas.

Textularia cf. **T. aciculata** d'Orbigny

Textularia aciculata d'Orbigny, Ann. Sci. Nat. **7**: pl. 11, figs. 1–4. 1826.

A few specimens that seem to belong to this species occur in the Helwan material. Specimens are slightly longer and thinner particularly at their initial end than in the typical form. This species appears in the Mediterranean deposits only since the Calabrian.

Textularia candeiana d'Orbigny

Textularia candeiana d'Orbigny, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères": 143, p. 1, figs. 25–27. 1839.

The distribution of this species in the Recent waters is cosmopolitan. In the modern Mediterranean it lives in the deeper waters, together with other representatives of the family Textulariidae.

Textularia neorugosa Thalmann

Textularia neorugosa Thalmann, Contr. Cushman Found. Foram. Res. **1**: 45. 950.

This cosmopolitan species occurs abundantly in the Helwan material. Test large, robust; chambers numerous with their lower margins excavated and with overhanging lateral lobulations; sutures irregularly rugose; peripheral margin of the test subacute. Specimens resemble those recorded from the Red Sea (Said, Contr. Cushman Found. Foram. Res., **1**: 5, pl. 1, fig. 5, 1929.).

Textularia pseudorugosa Lacroix

Textularia pseudorugosa Lacroix, Bull. Inst. Oceanogr. 582: 11, fig. 3 (in text). 1931.

This is a Mediterranean species known from the deeper Recent waters of this Sea. It is a well-defined species with a rapidly expanding keeled test, distinct sutures, and numerous chambers three times as wide as high.

Textularia sagittula Defrance

Textularia sagittula Defrance, Dict. Sci. Nat. **32**: 177. 1824; **53**: 344. 1828; Atlas Conch.; pl. 13, fig. 5. 1824.

This is a deep-water Mediterranean species that is recorded in small numbers in the outcrop studied.

Family MILIOLIDAE

Genus **Quinqueloculina** d'Orbigny, 1826

Quinqueloculina foliacea (Terquem)

Triloculina foliacea Terquem, Mém. Soc. Géol. France, ser. 3, **1**, pt. 3: 60, pl. 6, figs. 1a–c. 1878.

Specimens of this Lower Pleistocene species of the Mediterranean region are found in small numbers in the Helwan material. The test is somewhat foliated with the foliae extending in keel-like projections at the edge of the chambers. This is a distinct and well-defined species.

Family LAGENIDAE

Genus **Robulus** Montfort, 1808

Robulus cultratus (Montfort)

Robulina cultrata d'Orbigny, Ann. Sci. Nat. **7**: 287, no. 1. 1826; Modèles no. 82. 1826.

This cosmopolitan species is found in small numbers in the Egyptian material. According to Cushman and McCulloch (Allan Hancock Pacific Exped. **6** (6): 296, 1950) this species is recorded from deep waters at an average depth of 65 to 90 fathoms. Our specimens lack the keeled periphery of specimens of many authors although they resemble the forms recorded from the late Tertiary deposits of the Mediterranean region by the earlier workers.

Genus **Nodosaria** Lamarck, 1812

Nodosaria sulcata d'Orbigny

Nodosaria sulcata d'Orbigny, Ann. Sci. Nat. **7**: 253, no. 21. 1826. Cushman, Cushman Lab. Foram. Res. Special Publ. 13: 12, pl. 2, fig. 2; pl. 3, fig. 2. 1945.

A few specimens of this species, which is known from the Italian Pliocene and Recent Mediterranean, are recorded in Helwan. They are always 2-chambered and costate.

Family NONIONIDAE

Genus **Nonion** Montfort, 1808

Nonion ibericum Cushman

Nonion ibericum Cushman, U. S. Geol. Surv. Prof. Paper 191: 17, pl. 4, figs. 17, 18. 1939.

A few typical specimens of this species are found in Helwan. The small test, the rounded periphery, the umbilical plug, and the sigmoidal sutures characterize this species. This is a Pleistocene species recorded previously from Malaga, Spain.

Nonion pompiloides (Fichtel and Moll)

Nonion umbilicatula d'Orbigny, Ann. Sci. Nat. **7**: 293, pl. 15, figs. 10–12. 1826.
Nonion pompiloides Cushman, U. S. Geol. Surv. Prof. Paper 191: 19, pl. 5, figs. 9–12. 1939.

A few specimens of this species are recorded from Helwan. Specimens are smaller than is usual and are thinner. This is mainly a Mediterranean species known from the late Cenozoic and Recent waters of this region as well as from many other localities.

Genus **Elphidium** Montfort, 1808

Elphidium crispum Linné

Elphidium crispum Cushman, Contr. Cushman Lab. Foram. Res. **5**: 20, pl. 4, figs. 3, 4. 1929.

Several typical specimens of this Mediterranean species are recorded from the Helwan material.

Family POLYMORPHINIDAE

Genus **Pyrulina** d'Orbigny, 1830

Pyrulina fusiformis (Roemer)

Polymorphina fusiformis Roemer, Neues Jahrb. für Min., etc., 1838: 386, pl. 3, fig. 37.
Pyrulina fusiformis Cushman and Ozawa, Proc. U. S. Nat. Mus. **77** (art. 6): 54, pl. 13, figs. 3–8. 1930.

This deep-water species, recorded from modern seas and late Tertiary deposits of the Mediterranean region, is noted in small numbers in the Helwan material. Specimens differ slightly from those of the deep Atlantic by having more depressed sutures.

Family BULIMINIDAE

Genus **Bulimina** d'Orbigny, 1826

Bulimina acanthia Costa

Bulimina acanthia Costa, Atti. Accad. Pont. **8,** pt. 2: 335, pl. 13, figs. 35, 36. 1856.

A few specimens of this species occur in our material. The chambers are inflated particularly in the latter part of the test with slight overhanging but are not ornamented with any spines. This species is common in the Italian Pliocene.

Bulimina buchiana d'Orbigny

Bulimina buchiana d'Orbigny, Foram. Fossiles Bassin Viènne: 186, pl. 11, figs. 15–18. 1846.

This Miocene Mediterranean species is found in the Helwan material in abundance. Specimens are smaller than usual and the test is ornamented with extremely fine longitudinal costae. The chambers are inflated and there is no overhanging.

Bulimina costata d'Orbigny

Bulimina costata d'Orbigny, Ann. Sci. Nat. **7:** 269, no. 1, 1826.

This species occurs in abundance in the Egyptian material. Specimens are typical. This species seems to be one of the autochthonous forms of the Mediterranean region that has been recorded from since the Miocene to the Recent. It is also recorded off the coast of Ireland.

Bulimina elongata d'Orbigny

Bulimina elongata d'Orbigny, Ann. Sci. Nat. **7:** 269, no. 9. 1826.

This species is found in abundance in the Egyptian material. Specimens have an elongate slender test, inflated and angled chambers, and smooth polished wall. Our specimens resemble those recorded from the Mediterranean area. This species ranges from the Eocene to the Recent and seems to have its origin in the Mediterranean region.

Bulimina gibba Fornasini

Bulimina gibba Fornasini, Mem. Accad. Sci. Ist. Bologna, ser. 5, **9:** 378, pl. O, figs. 32–34. 1901.

This species was recorded in the top part of the section. Specimens are typical except that very faint costae appear on the otherwise smooth and polished test. The terminal basal spine is lacking, but there are short spines that ornament the base. The chambers are distinct, regularly triserial, slightly inflated and offset so as to give a slight twist to the test.

Bulimina inflata Seguenza

Bulimina inflata Seguenza, Atti Accad. Gioenia Sci. Nat., ser. 2, **18:** 25, pl. 1, fig. 10. 1862.

This Mediterranean and east Atlantic species occurs in the Egyptian material in small numbers. Test widest near top with the last whorl forming about one-third of the entire length. This species is characterized by having broad costae, a rapidly tapering test and chambers that do not overhang. This is one of the species that has probably invaded the Mediterranean in a cold period. It is common in the Pleistocene of Italy. Records of this species in older sediments need revision.

Bulimina pupoides d'Orbigny

Bulimina pupoides d'Orbigny, Foram. Fossiles Bassin Viènne: 185, pl. 11, figs. 11, 12. 1846.

A few specimens of this species are found in the top beds of the Helwan section. They approach in their structural detail those recorded from the Mediterranean region. Specimens lack, however, the lip and the tooth in the aperture. This species has a long record but is common in the late Cenozoic of the Mediterranean region.

Genus **Bolivina** d'Orbigny

Bolivina aenariensis (Costa)

Brizalina aenariensis Costa, Atti Accad. Pont. **8,** pt. 2: 297, pl. 15, figs. 1A, B. 1856.

This is a late Tertiary Mediterranean species that has been much confused. Specimens look very much similar to those recorded from the Pliocene of Coroncina, Italy, in having an elongate test without a spine at the base, sutures slightly limbate and strongly curved, and the characteristic costae on the surface extending from the base to the middle of the test.

Bolivina catanensis Seguenza

Bolivina catanensis Seguenza, Atti Accad. Gioenia Sci. Nat., ser. 2, **18**: 29, pl. 2, figs. 3, 3a, 3b. 1862.

This is a typical Mediterranean species that is recorded from the Pleistocene of Italy. Specimens are compressed and have an elongate test which is occasionally twisted in its initial end.

Bolivina cf. B. compacta Sidebottom

Bolivina robusta var. *compacta* Sidebottom, Mem. Proc. Manchester Lit. Phil. Soc. **49** (5): 15, pl. 3, fig. 7. 1905.

A few specimens that seem to belong to this species are found in Helwan. Specimens differ from typical in having a more roughened exterior, a rounded initial end, and a more elongate test. This is a Mediterranean species that has been recorded from many Recent seas at different depths.

Genus **Reussella** Galloway, 1933

Reussella spinulosa (Reuss)

Verneuilina spinulosa Reuss, Denkschr. Akad. Wiss. Wien. **1**: 374, pl. 47, fig. 12. 1850.
Verneuilina spinulosa Reuss, Denkschr. Akad. Wiss. Wien **1**: 374, pl. 47, fig. 12. 1850.

A few typical specimens of this cosmopolitan species are found in the Helwan material.

Genus **Uvigerina** d'Orbigny, 1826

Uvigerina costai Said, new name

Uvigerina striata Costa (non d'Orbigny), Atti Accad. Pont. **7** (fasc. 2): p. 266, pl. 15, fig. 3. 1856.—Cushman and Todd, Contr. Cushman Lab. Foram. Res. **17**: 71, pl. 17, fig. 4. 1941.

Specimens resembling Costa's figures for this species have been found in the Helwan material. Test moderate in size for the genus, elongate, circular in transverse section, base tapering; chambers equal, rather large, slightly inflated; sutures distinct; wall with fine longitudinal striae interrupted at the sutures, extending through the length of the test equally; aperture at the end of a short neck, very slightly lipped.

This species deserves a new name as *U. striata* has been used by d'Orbigny in 1826 for a Recent species.

Genus **Unicosiphonia** Cushman, 1935

Unicosiphonia cf. U. crenulata Cushman

Unicosiphonia crenulata Cushman, Contr. Cushman Lab. Foram. Res. **11**: 81, pl. 12, figs. 9, 10. 1935.

A few specimens of this species are found in Helwan section. Specimens are slightly different in having a more rounded initial end that does not show any traces of biseriality and in having more poorly developed crenulations. This is the first record of this species in the Mediterranean region.

Family ROTALIIDAE

Genus **Discorbis** Lamarck, 1804

Discorbis orbicularis (Terquem)

Discorbina orbicularis H. B. Brady, Rep. Voy. *Challenger*, Zoology, **9**: 647, pl. 88, figs. 4–8. 1884.

This is mainly a Mediterranean east Atlantic species of wide geographical distribution in Recent waters. It is also recorded from the late Tertiary deposits of the Mediterranean region, although it seems not to have invaded the Recent Mediterranean except in the Calabrian time.

Family AMPHISTEGINIDAE

Genus **Asterigerina** d'Orbigny, 1839

Asterigerina rhodiensis Terquem

Asterigerina rhodiensis Terquem, Mém. Soc. Géol. France, ser. 3, **1**, pt. 3: 31, pl. 3, figs. 1–4. 1878.

Typical specimens of this species recorded from the lower Pleistocene of the Isle of Rhodes are recorded in abundance in the Helwan material.

Family GLOBIGERINIDAE

Genus **Globigerina** d'Orbigny, 1826

Globigerina bulloides d'Orbigny

Globigerina bulloides d'Orbigny, Ann. Sci. Nat. **7**: 277, no. 1. 1826; Modèles nos. 17, 76. 1826.—Cushman, Contr. Cushman Lab. Foram. Res. **17**: p. 38, pl. 10, figs. 1–13. 1941.

Typical and well-preserved specimens of this species are recorded in large numbers at the top beds of the Helwan section. They agree in detail with d'Orbigny's original descriptions and models. The occurrence of this species in abundance indicates conditions where the effect of freshening of water was not felt.

Family ANOMALINIDAE

Genus **Planulina** d'Orbigny, 1826

Planulina sp.

Test much compressed, partly evolute, earlier chambers visible from both sides; chambers

numerous; sutures distinct, flush with the surface, curved slightly toward the periphery; ventral side umbilicate; wall perforate, smooth; aperture at the base of the last chamber at the median line. The compressed large test and the wide circular umbilicus of the ventral side distinguish this species found in very small numbers in the top bed of the Helwan section.

Genus **Cibicides** Montfort, 1808

Cibicides gibbosa (Terquem)

Anomalina gibbosa Terquem, Mém. Soc. Géol. France, ser. 3, **1**, pt. 3: 24, pl. 2, fig. 7. 1878.
Cibicides gibbosa Said, Cushman Lab. Foram. Res. Special Publ. 26: 43, pl. 4, fig. 19. 1949.

Typical specimens of this species hitherto recorded from the Lower Pleistocene of the Isle of Rhodes and the Recent Red Sea are found in large numbers in the Helwan material. This species is biconvex and is coarsely perforate. It possesses the apertural characteristics of the genus *Cibicidoides* Brotzen, 1936. The author prefers to place this species in the genus *Cibicides* until the validity of the genus *Cibicidoides* is cleared (see Hofker, 1951, *Siboga* Exped. III).

Cibicides lobatulus (Walker and Jacob)

Truncatulina lobatula H. B. Brady, Rep. Voy. *Challenger*, Zoology, **9**: 660, pl. 92, fig. 10; pl. 93, figs. 1, 4, 5; pl. 95, figs. 4, 5. 1884.

Typical specimens of this cosmopolitan species are found in the Helwan material. According to Cushman this is a "very common species in cool waters." There are records, however, of this species in deeper tropical waters and in tropical shallow seas, but such records probably need revision.

Cibicides refulgens Montfort

Cibicides refulgens Cushman, U. S. Nat. Mus., Bull. 104, pt. 8: 116 pl. 21, figs. 2a–c. 1931.

This is a cosmopolitan species that is particularly abundant in cool waters of the modern seas, according to H. B. Brady.

Cibicides rhodiensis (Terquem)

Truncatulina rhodiensis Terquem, Mém. Soc. Géol. France, ser. 3, **1**, pt. 3: 21, pl. 1, fig. 26. 1878.
Cibicides rhodiensis Said, Cushman Lab. Foram. Res. Special Publ. 26: p. 42, pl. 4, fig. 16. 1949.

This species recorded from the Lower Pleistocene of the Isle of Rhodes and the Recent Red Sea is found in abundance in Helwan. The distribution of this species can be explained only if we assume a temporary connection to have existed between the Mediterranean and the Red Sea sometime in the Pleistocene. Specimens are typical and abundant.

REFERENCES

BALL, J. *Contributions to the geography of Egypt: Survey of Egypt*. 1939.

BLANCKENHORN, M. *Neues zur Geologie und Paleontologie Aegyptens: IV. Das Pliozan*. Zeitschr. deutschen geol. Ges. **53**: 307–502. 1903.

———. *Handbuch der regionalen Geologie, Aegypten*. Heidelberg, 1921.

COLOM, G. *Una contribución al conocimiento de los foraminíferos de la Bahia de Palma de Mallorca*. Notas y Res. Inst. Español Oceanografía, ser. 2, no. 108. 1942.

COX, L. R. *Notes on the post-Miocene Ostereidae etc*. Proc. Malac. Soc. London **48**, pts. 4 and 5: 165–209. 1929.

HUME, W. F., and LITTLE, O. H. *Raised beaches and terraces of Egypt*. C. R. Union Geogr. Intern., Paris (session 14, 1926): 9–15. 1928.

MOVIUS, H. M. *Villafranchian stratigraphy in southern and southwestern Europe*. Journ. Geol. **57**: 380–412. 1949.

NAPOLI-ALLIATA, E. DI. *Contributo all conoscenza della stratigrafia del Pliocene e del Calabriano nella regione di Rovigo*. Riv. Ital. Paleontologia **52**: 19–36. 1946.

PICARD, L. *The structure and evolution of Palestine*. Bull. Geol. Dept. Hebrew University **4**, Nos. 2–4. 1943.

SAID, R., and KAMEL, T. *Recent littoral Foraminifera from the Egyptian Mediterranean coast between Saloum and Bardia*. (In press.)

SAID, R., and YALLOUZE. *Miocene fauna from Gebel Oweibid, Egypt*. Bull. Inst. Egypte. (In press.)

SANDFORD, K. S., and ARKELL, W. J. *Paleolithic man and the Nile Valley in Lower Egypt*. Oriental Inst. Publ. **46**. 1939.

PALEONTOLOGY.—*A new species of* Cymbiocrinus *from the Pitkin.* HARRELL L. STRIMPLE, Bartlesville, Okla. (Communicated by Alfred R. Loeblich, Jr.)

The form described below as *Cymbiocrinus pitkini*, n. sp., is from the Pitkin formation, Chester, of the Cookson Hills southeast of Fort Gibson, Okla. Strong affinity with Pennsylvanian representatives of the Ampelocrinidae is indicated.

DENDROCRINOIDEA Bather

AMPELOCRINIDAE Kirk

Cymbiocrinus Kirk, 1944

Cymbiocrinus pitkini, n. sp.

FIG. 1

Description.—The crown of the holotype is 43 mm high; the dorsal cup is about 2.5 mm high by 9.6 mm wide.

Dorsal cup is shallowly bowl-shaped, with shallow basal concavity. IBB small, confined to the basal concavity and entirely covered by the pentagonal shaped proximal columnals. BB are five, small, and form sides of the basal concavity but curve upward to participate slightly in the lateral walls of the cup. RR are five large elements with width slightly greater than length. The single anal plate is quadrangular, resting evenly on the truncated upper edge of post. B, and does not extend above the cup height.

There are 10 long, slow-tapering, uniserial arms. PBr_1 is low, wide, with lateral sides tapering slightly. Axillary PBr_2 is large, lateral sides expanding for a short distance thence sloping rapidly to the apex of the plate. SBrBr are remarkably regular segments. Each SBr appears to have two well-developed though thin pinnules of moderate length, one on each lateral side. There is no demonstrated tendency toward fusion, or syzygy, other than between PBr_1 and PBr_2.

The tegmen, or anal sac, has not been observed.

Remarks.—The arms of *C. pitkini* serve most readily to distinguish it from other described species. The regularity of the relatively thick SBrBr, with no tendency toward cuneiformity or syzygial pairs, in unique for known species referred to this genus. *C. gravis* Strimple (1951), from the slightly older Fayetteville formation, has cuneiform arms, and the axillary PBr_2 has no lateral sides, so that the first SBr is in contact with PBr_1. The basal plates of *C. gravis* are more pronounced and bulbous than those of *C. pitkini*. Both species have pentagonal stems and in that respect are distinct from all other known species of *Cymbiocrinus*.

Occurrence.—Approximately 4 miles southeast of Greenleaf Lake in bluff overlooking the Arkansas River, Cookson Hills, Okla.; upper Pitkin limestone formation, Chester, Mississippian.

Types.—Holotype and paratype collected by the author. To be deposited in the U. S. National Museum.

REFERENCES

KIRK, EDWIN. Amer. Journ. Sci. **242**: 233–245. 1944.

STRIMPLE, HARRELL L. Bull. Amer. Pal. Soc. **33**(137): 18, 19, pl. 4, figs. 4–6. 1951.

FIG. 1.—*Cymbiocrinus pitkini*, n. sp. View of holotype from the posterior, × 1.7

ENTOMOLOGY.—*The immature stages of* Sarcophaga cooleyi, S. bullata, *and* S. shermani (*Diptera: Sarcophagidae*). VERNE F. NEWHOUSE, DAVID W. WALKER, and MAURICE T. JAMES, State College of Washington.

This paper describes the immature stages of three species of saprophagous flies, *Sarcophaga cooleyi* Parker, *S. bullata* Parker, and *S. shermani* Parker. These flies show an extremely close relationship to one another as adults, and this affinity is even more completely borne out by comparative study of their larval stages.

Greene (1925) described briefly and illustrated the puparia of *Sarcophaga cooleyi* and *S. bullata*. The larva of *S. bullata*, undoubtedly third stage though not expressly so stated, is also briefly discussed and figured. Knipling (1936) described more fully the first instar of *S. bullata*, in comparison with some other species of the same genus, and illustrated the cephalopharyngeal apparatus, the entire larva, and the pattern and morphology of the setulae. Root (1923) discussed the morphology and specific characters of sarcophagid larvae including *bullata*, with special emphasis on spiracular characters. As far as we can ascertain there has been no published study of the larval forms of *S. shermani*.

This present study was initiated with the hope of distinguishing more clearly these important, closely related species and of facilitating their identification in the future.

A great amount of the preliminary work on this study was done during the summer of 1951 by David W. Walker and presented in a thesis submitted as partial fulfillment of requirements for a M.S. degree in entomology at the State College of Washington. Material for Mr. Walker's study, as well as for this one, was obtained through studies supported in part by funds provided for biological and medical research by the State of Washington, Initiative Measure no. 171.

MATERIALS AND METHODS

Material for study was taken from laboratory colonies, reared at the State College of Washington, from stocks originally collected in various areas of the State. Samples were taken from well established colonies which had been carried through as many as 27 generations. Although larvae of all ages were examined, the most fully developed of each instar were selected wherever possible as it was felt that this would show most typically the anatomical characters of that instar.

In all stages of all species except one (*Sarcophaga bullata*) second instar, of which 18 specimens were studied), at least 50 and as many as 300 specimens were examined.

For fixation, eggs and larvae were placed in water and heated to the boiling point for 30 seconds. The water was then decanted and the specimens were carried through 70 per cent alcohol for 24 hours, into absolute alcohol for a similar time period, drained, placed in xylene for 24 hours, and finally stored in clove oil. Those for gross examination were retained in 70 per cent alcohol. Larvae for the purpose of illustration were removed from alcohol, cut in half, and boiled in concentrated potassium hydroxide until the integument was clear and the body contents removed. The cephalopharyngeal apparatus was examined under clove oil at magnification of 45 diameters, and all drawings were made with the aid of a micrometer grid. As sarcophagid flies are normally larviparous, eggs were obtained by dissection or by forcing them from the abdomen of gravid flies before the development of the larvae.

Sarcophaga cooleyi Parker

Sarcophaga cooleyi Parker, Can. Ent. **46**: 417–423. 1914.

Egg.—White; smooth; slightly curved, tapered moderately toward one end. Length 1.10 mm, diameter 0.333 mm.

First stage larva.—White; muscidiform; length 1.50 to 4.75 mm, diameter 0.75 mm; cuticle nearly smooth. Anterior and/or posterior margin of each segment possessing many hooklike setulae arranged around the segmental circumference in the form of a band. Spinous bands very prominent; setulae dark brown in color; bands complete on segments 2 through 12. Band on segment 2 (first thoracic) very broad, especially ventrally just posterior to mouth hooks. Bands

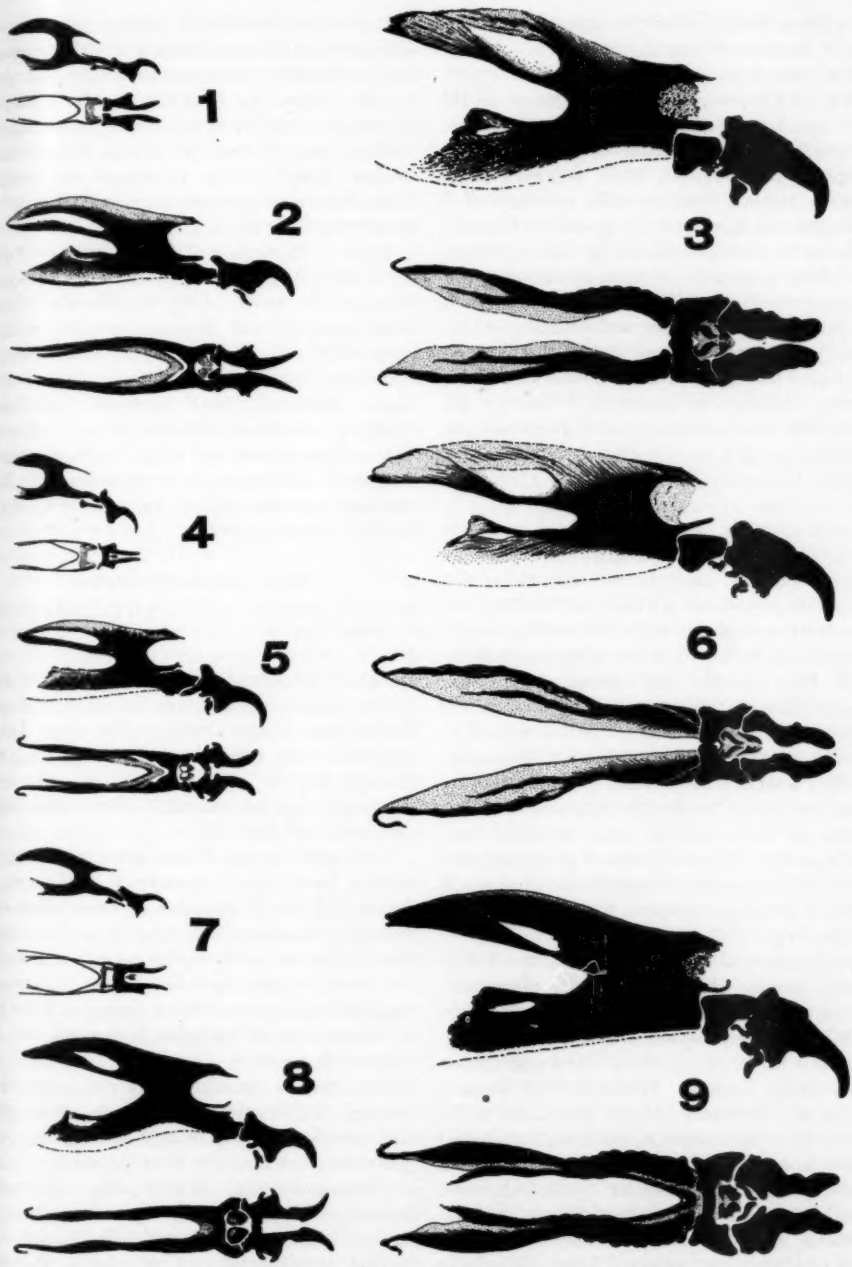
on anterior margins usually complete on segments 2 through 9; incomplete on segments 10 through 12. Bands on posterior margins usually absent on segments 2 through 4; complete on segments 9 through 11; and incomplete on segments 5 through 8. Dorsal and lateral portions of bands on segments 5 through 12 not as heavy or dark as on the more anterior segments. Larvae metapneustic; prothoracic spiracles non-functional but may be visible beneath integument, especially just before the molt. Caudal pair of spiracles situated in a shallow cavity, each unit consisting of two elongated spiracular openings lying side by side, their inner sides confluent and their axis dorsoventral. Distance between each spiracle approximately equal to the width of one spiracle. Peritreme absent. Posterior tubercles weakly developed; may appear to be absent. Opening of spiracular cavity bordered with nearly complete ring of setulae or darkened cuticular papillae. Anal tubercles small but prominent. Anal opening surrounded by patch of black setulae.

Cephalopharyngeal skeleton (Fig. 1).—Labial sclerite well formed, heavily pigmented. Mouth hooks fused, or in process of fusing posteroventrally. Hooks arising from anterodorsal corner of sclerite, extending forward in a smooth even curve, terminating in a sharp point above the median longitudinal axis of the sclerite.[1] Anterior lower edge of sclerite more or less sharp and truncate. Hypostomal sclerite small; from a lateral aspect wedge-shaped, broadened posteriorly, narrowed anteriorly; from a ventral aspect much less pigmented, broad and thick posteriorly, extending anteriorly as two thin lateral processes. Small accessory sclerite between mouth hooks not visible. Dental sclerite apparently absent. Pharyngeal sclerite well developed; well pigmented. Anterior process of ventral portion possessing a small sclerotized extension which protrudes posteriorly. Upper posterior end of ventral cornu heavily pigmented, protruding upward and outward beyond lower edge. Over-all length of skeleton 0.455 to 0.546 mm.

Second stage larva.—White; muscidiform; length 5.0 to 9.0 mm, diameter 0.75 to 1.75 mm. Entire cuticle covered with minute papillae except the anterior margin of each segment which possesses many hookline setulae; anterior spinous bands prominent, setulae dark brown in color. Lateral margins of oral opening possessing minute ridges which radiate from the opening. Band on segment 2 sometimes divided, either with a heavy patch of setulae dorsally and ventrally, or with the band complete but with its lateral portions weakly developed; band sometimes obscured as a result of retraction of the cephalic segment. Bands on anterior margins usually complete on segments 2 through 9 or 10; incomplete on segments 10 or 11 through 12. Bands on posterior margins usually absent on segments 2 through 4; incomplete on segments 5 through 7; complete on segments 8 through 11. Larvae amphipneustic; prothoracic spiracle near posterior margin of segment 2 (first thoracic), prominently divided into 12 to 15 digits, each terminating in an oval spiracular opening. Caudal spiracles, each composed of two slit-like openings, situated in a deep cavity; peritreme present but weakly developed. Spiracles almost contiguous at upper inner border. Posterior tubercles humplike; posterior cavity bordered with complete ring of setulae or darkened integumental papillae. Anal tubercles prominent and fingerlike. Anal opening surrounded by small patch of black setulae.

Cephalopharyngeal skeleton (Fig. 2).—Labial sclerite heavy, deeply pigmented; hook extending from upper anterior corner of sclerite outward and downward in a smooth curve, but terminating above the median longitudinal axis of the sclerite. Lower anterior corner of sclerite possessing a rounded toothlike protuberance; the sliverlike dental sclerite clearly visible just posterior to this protuberance. Accessory sclerite slender, lying between posterior ends of labial sclerites, extending downwards below the edge of the labial sclerite so as to give the impression of a small ventral process on the sclerite when viewed from a lateral aspect. Hypostomal sclerite narrowed anteriorly, fused basely to the pharyngeal sclerite. Paired infrahypostomal sclerites weakly developed, lightly pigmented; visible from dorsal aspect between anterior arms of hypostomal sclerite. Pharyngeal sclerite lightly pigmented; parastomal sclerite rather thick, blunt; dorsopharyngeal sclerite lightly pigmented, flattened anteriorly. Ventral cornu thickened posteriorly; the upper edge bending dorsally and possessing a small, weakly developed fenestra, the lower edge

[1] The median longitudinal axis is here defined as a line drawn through the body of the sclerite from back to front midway between the posterior corners and roughly parallel to the lower edge.



FIGS. 1–9.—Cephalopharyngeal skeletons of *Sarcophaga*, lateral (upper figure) and ventral (lower figure) views: 1, *S. cooleyi*, first instar; 2, same, second instar; 3, same, third instar. 4, *S. bullata*, first instar; 5, same, second instar; 6, same, third instar. 7, *S. shermani*, first instar; 8, same, second instar; 9, same, third instar. Drawn by Verne F. Newhouse. Drawings in each case based on representative specimens of the series studied.

extending posteriorly. Over-all length of skeleton usually about 0.966 mm.

Third stage larva.—White, muscidiform; length 8.75 to 20.25 mm; at maturity (average of 10) 19.17 mm. Diameter 1.5 to 4.5 mm. Entire cuticle covered with minute papillae except the anterior margin of each segment which possesses many hooklike setulae. Spinous band on segment 2 (first thoracic) incomplete; large patch of setulae posterior to mouth hooks, similar patch dorsally but lateral extensions of band incomplete. Oral margin posessing small ridges which radiate from the oral cavity, extending well laterally on the cephalic segment. Spinous bands complete on segments 2 through 12. Bands on anterior margins usually complete on segments 2 through 10; incomplete on segments 11 and 12. Bands on posterior margins usually absent on segments 2 through 4; incomplete on segments 5 through 8; and complete on segments 9 through 11. Prothoracic spiracles prominent, divided into 9 to 17 digits, but more commonly into 14 to 16. Caudal spiracles, each divided into three slitlike openings, situated in a deep cavity. Peritreme prominent, strongly developed; extending dorsally and medially to form a rather sharp upper inside angle, then laterally and ventrally in a rather regular curve to terminate directly beneath the innermost slit. Ratio of width of one spiracle to distance between spiracles 5.77 to 3.75 (average of 10). Posterior tubercles slender and fingerlike. Spiracular cavity bordered by ring of microscopic setulae or dark papillae. Anal tubercles large and fingerlike, depending from a prominent anal process. Anal opening surrounded by small patch of black setulae in contrast to colorless setulae of body in general.

Cephalopharyngeal skeleton (Fig. 3).—Labial sclerite strongly developed, heavily pigmented; hook arising from upper anterior angle of sclerite, extending straight outward, then bending downward in a rather sharp curve. Front angle below tooth sharp, truncate. Dental sclerite strongly developed. Accessory sclerite protrudes below lower edge of labial sclerite, appearing from lateral aspect as a process of that sclerite. Hypostomal sclerite roughly rectangular, more narrowed anteriorly than posteriorly. Paired infrahypostomal sclerites visible between and below arms of hypostomal sclerite. Pharyngeal sclerite heavily pigmented medially, but lightly pigmented distally. Dorsopharyngeal sclerite lightly pigmented except for extreme upper anterior flattened area. Parastomal sclerite rather heavy, blunt. Dorsal cornu possessing an elongated, narrow fenestra; ventral cornu thickened posteriorly, possessing a small, weakly developed fenestra in upper posterior corner. Lower edge of ventral cornu (sometimes almost indiscernible) convex. Lines of axis of dorsal and ventral cornu divergent posteriorly. Overall length of skeleton usually about 1.70 mm.

Pupa.—Elliptical, dull dark red; 8.5 to 11 mm in length, 3 to 5 mm in diameter. Opening of spiracular cavity oval to elliptical. Spiracular plate on roof of posterior cavity shining deep red-brown; slits almost white in contrast. Tubercles surrounding posterior cavity flattened, distorted. Anal tubercles prominent. Posterior tubercles connected to anal tubercles by a broad, rounded ridge. Spinous bands complete on segments 3 through 12. Prothoracic spiracles evident, but number of digits usually not discernible.

Sarcophaga bullata Parker

Sarcophaga bullata Parker, Can. Ent. **48**: 359–364. 1916.

Egg.—Unfertilized egg at time of copulation white, translucent; 0.49 mm in length, 0.30 mm in diameter. Shape almost as hen's egg. Entire surface covered with minute depressions or pits.[2] Mature egg as in *cooleyi*; length 1.25 mm. Distinctly tapered anteriorly. Developing larva distinctly visible within.

First stage larva.—White, muscidiform, as in *cooleyi*. Newly hatched larva 2 to 2.5 mm in length; 0.5 mm in diameter. Spinous bands considerably more prominent than in *cooleyi*, almost black in color; not divided to as great an extent by plicae except ventrally. Bands on anterior margins usually complete on segments 2 through 7; incomplete on segments 8 through 10; and absent on segments 11 and 12. Bands on posterior margins usually absent on segments 1 through 6; incomplete on segments 5 through 8; and complete on segments 9 through 11. Anal tubercles more fingerlike than in *cooleyi*.

Cephalopharyngeal skeleton (Fig. 4).—Labial sclerite well developed. Mouth hook arising as in *cooleyi*, but more slender and raised higher from median longitudinal axis of sclerite. Posterior

[2] This degree in development unfortunately could not be accurately matched in the other species, therefore cannot be compared.

articulation process extending laterally, very slender. Accessory sclerite visible between labial sclerites. Hypostomal sclerite thickened posteriorly. Anterior extensions of ventral cornu not possessing a dorsal process. Pharyngeal sclerite smaller and lighter in pigment than in *cooleyi*. Ventral cornu not extending dorsally, but appearing bifurcated apically as a result of incomplete sclerotization. Over-all length of skeleton 0.433 mm.

Second stage larva.—Much as in *cooleyi*. Larva apparently slightly larger. Length 5.25 to 9.25 mm, diameter 0.75 to 2.25 mm. Setulae of cuticle black; bands on segments 2 through 12 complete. Band on segment 2 very broad, especially ventrally. Bands on anterior margins usually complete on segments 2 through 7; incomplete on segments 10 through 12. Bands on posterior margins usually absent on segments 2 through 4; incomplete on segments 5 through 8, complete on segments 9 through 11. Narrow band of setulae partially surrounding base of anal prominence.

Cephalopharyngeal skeleton (Fig. 5).—Labial sclerite more slender than in *cooleyi*. Hook extending below the median logitudinal axis of the sclerite. Small tooth on lower anterior edge of sclerite more prominent, sharper than in *cooleyi*. Dental sclerite obvious. Slender accessory sclerite larger, extending more ventrad and caudad, appearing from lateral aspect as a long protuberance on labial sclerite. Hypostomal and infrahypostomal sclerites as in *cooleyi*. Pharyngeal sclerite lightly pigmented. Parastomal sclerite slender, usually bent up at the tip. Dorsopharyngeal sclerite more heavily pigmented, anterior flattening more pronounced. Dorsal and ventral cornua fenestrate; ventral cornu more slender, lower edge more straight than convex. Overall length of skeleton about 0.866 mm.

Third stage larva.—White, muscidiform, much as in *cooleyi*. Larva slightly larger; length 9.50 to 21.00 mm; at maturity (average of 10) 20.17 mm. Setulae of cuticle may show blackening of tips. Bands on anterior margins usually complete on segments 2 through 8; incomplete on segments 9 through 12. Bands on posterior margins usually absent on segments 2 through 4; incomplete on segments 5 through 7; complete on segments 8 through 11. Posterior tubercles fingerlike; anal tubercles long and prominent. Ratio of width of one spiracle to distance between spiracles 5.80 to 3.95 (average of 10).

Cephalopharyngeal skeleton (Fig. 6).—Labial sclerites strongly developed. Hook arising from upper anterior angle, extending straight outward, then downward in a slightly more regular curve than in *cooleyi*. Dental sclerite slightly less developed. Accessory, hypostomal, and infrahypostomal sclerites as in *cooleyi*. Pharyngeal sclerite much more compressed. Parastomal sclerite more slender, usually tilted upward anteriorly. Dorsal and ventral cornua fenestrate. Lines of axis of dorsal and ventral cornu not divergent posteriorly, but roughly parallel. Overall length of skeleton 1.56 mm.

Pupa.—As in *cooleyi*; perhaps slightly larger. Length 9.5 to 11.5 mm.

Sarcophaga shermani Parker

Sarcophaga exuberans Authors (not Pandellé, Rev. Ent. **15**: 186. 1896).

Sarcophaga shermani Parker, Bull. Brooklyn Ent. Soc. **14**: 41–46. 1919; Ann. Mag. Nat. Hist. **9**(11): 124. 1923.

Egg.—Indistinguishable from *cooleyi*; length about 1.50 mm.

First stage larva.—As in *cooleyi*. Length of mature larva 5.50 mm, diameter 1.0 mm. Anal tubercles usually not as prominent as in *cooleyi*. Setulae of spinous bands black in color. Bands on anterior margins usually complete on segments 2 through 11; absent on segment 12. Bands on posterior margins absent on segments 2 through 4; incomplete on segment 5; complete on segments 6 through 11.

Cephalopharyngeal skeleton (Fig. 7).—Labial sclerite more slender than in either *cooleyi* or *bullata*; tooth arising at higher angle in relation to axis of sclerite. Dorsal cornu of pharyngeal sclerite relatively longer and more slender. Overall length of skeleton 0.533 mm.

Second stage larva.—As in *cooleyi*. Length 5.50 to 8.25 mm, diameter 1.0 to 1.75 mm. Spinous bands on anterior margins usually complete on segments 2 through 9 or 10; incomplete on segments 10 or 11 through 12. Bands on posterior margins absent on segments 2 through 4; incomplete on segments 5 through 7; complete on segments 8 through 11. Bands on second and third segments sometimes incomplete and indistinct. Posterior tubercles humplike but prominent; anal tubercles more fingerlike. Darkened band surrounding spiracular cavity not as prominent as in *cooleyi*. Narrow band of setulae at ventral base of anal tubercles.

Cephalopharyngeal skeleton (Fig. 8).—Labial

sclerite with hook arising at high angle. Dental, accessory, hypostomal and infrahypostomal sclerites prominent. Pharyngeal sclerite well formed and quite heavily pigmented. Dorsal and ventral cornua fenestrate. Cornua sometimes divergent posteriorly. Lower surface of ventral cornu almost concave in outline. Over-all length of skeleton 1.05 mm.

Third stage larva.—As in *cooleyi*. Length 8.00 to 18.00 mm, diameter 1.5 to 4.0 mm; at maturity (average of 10) 16.79 mm. Setulae of cuticle may be black at tip or colorless. Bands on anterior margins usually complete on segments 2 through 10; incomplete on segments 11 and 12. Bands on posterior margins usually absent on segments 2 through 4; incomplete on segments 5 through 7; complete on 8 through 11. Ratio of width of one spiracle to distance between spiracles 5.4 to 2.5. (Average of 10) One specimen, obviously atypical, was observed with three slits in the left spiracle and two in the right.

Cephalopharyngeal skeleton (Fig. 9).—Similar to *cooleyi*. Mouth hook with small tooth on the underside at base. Dental sclerite robust. Parastomal sclerite slender and usually bent up at the tip. Pharyngeal sclerite quite heavily pigmented. Dorsal and ventral cornua fenestrate. Dorsal cornu comparatively more slender. Cornua divergent posteriorly. Lower edge of ventral cornu flattened or concave in profile. Over-all length of skeleton 1.43 mm.

Pupa.—As in *cooleyi*. Ridge connecting anal tubercles and posterior tubercles usually weakly developed or absent.

LITERATURE CITED

GREENE, CHARLES T. *The puparia and larvae of sarcophagid flies*. Proc. U. S. Nat. Mus. **66**(29): 1–26. 1925.

KNIPLING, EDWARD F. *A comparative study of the first-instar larvae of the genus* Sarcophaga *(Calliphoridae: Diptera), with notes on the biology*. Journ. Parasit. **22**(5): 417–454. 1936.

ROOT, FRANCIS M. *Notes on larval characters in the genus* Sarcophaga. Journ. Parasit. **9**(4): 227–229. 1923.

ENTOMOLOGY.—*Some work of the periodical cicada*. E. A. ANDREWS, Johns Hopkins University. (Communicated by Paul H. Oehser.)

The periodical or seventeen-year cicada, found only in North America, has a subterranean life years longer than that of numerous other cicadas and an aerial life of a few months. Joining these two major parts of its life history are two briefer links: a few weeks late in summer when the eggs left by females inside the wood of twigs develop into minute young nymphs, which enter the ground; and a few weeks in spring when the subterranean nymphs come near the surface and become ready to emerge and transform into adults or imagoes. Some of the work done by the surface dwellers as observed at Baltimore, Md., is here described.

THE LAST DWELLING

During their years under ground the young cicadas shed from time to time, grow rapidly, and make successive mud dwellings attached to roots from which the nymphs suck their nutriment, being parasites upon many trees. In Baltimore Potter (1839) observed the largest of these dwellings some 18 inches below the surface. Each was a rough ball of earth 1½ to 2 inches long and three-fourths of an inch wide, lined by smooth mud, and contained one nymph. Emerging from such last feeding chambers the nymphs dig upward and construct somewhat different dwellings (Fig. 1). Within the mud tubes they rest some weeks till ready for emergence and transformation. These last dwellings have the advantage of safety some inches below the surface, along with quick access to the surface when the proper time comes. Each dwelling (Fig. 1) has rounded ends above and below as in previous subterranean dwellings, but these are connected by a long shaft and are commonly 150 to 350 mm long, though they may be longer or much shorter. In this shaft the lymph climbs up close to the surface or falls rapidly down to the bottom to escape attacks. In cross section the shaft is circular or sometimes elliptical, being wider than deep, and is about either 10 or 15 mm in diameter. Dwellings of these two sizes occur in the same places, but one or the other predominates, a fact that harmonizes with the occurrence here of a larger and a smaller variety of cicada of which one or the other is more abundant under certain trees. Also the larger bores were found where the larger cicadas emerged; that is, the bores were made to fit the cicadas.

The lining of the shaft is smooth mud a few millimeters thick, sharply defined from the lumen, but fading off gradually into the surrounding earth. Shafts are by no means always straight, or of uniform diameter, but may be sinuous and present swollen regions 20 mm wide. But I have not seen regular swellings near the upper end, as noted in another part of Maryland by Snodgrass (1921). Following his method we filled shafts under a purple beech tree with plaster of Paris and obtained such demonstrations of the abundance and character of these dwellings as shown in Fig. 2. The topsoil was such a mass of small stones and roots as to indicate that the nymph must have cut off small roots in order to advance so many inches. Large obstacles were often avoided by change of direction, but at times small stones or roots projected into the lumen, covered with lining mud, and reduced the cavity from its normal 15 mm to a mere 10 mm in diameter. Staining of the plaster casts by topsoil or by clay showed that the lining material came from that level and was not brought up from below, which is in harmony with descriptions of the way in which cicada dwellings are made, namely, by forcing the earth laterally aside into its walls and not by carrying it away, as is done by many burrowing animals.

FIG. 1.—Plaster cast of common or typical dwelling showing bottom chamber, long shaft, and dome above connected to surface by short exit passageway added by escaping larva. One-half natural size.

FIG. 2.—Plaster cast of nine dwellings in natural association, lengths, widths, and shapes, but with upper ends obscured in excess surface plaster. About half natural size. Photograph by Charles H. Weber.

The chief implements used in making cavities in the earth, according to Marlatt (1907) and Snodgrass (1921), who observed the work in vessels of loose earth, are the big first legs (Fig. 3). Here, as in the other legs, the terminal segment is used chiefly in walking and may be folded down when not needed; the second segment from the tip is used to pick off particles of earth. The third segment is the largest and like a powerful thumb acts with the opposing second as a forceps to pick up pellets of earth and small stones. The minute particles picked loose from the earth are raked together by the tip segment to make a pellet, which the forceps can carry or shove into the walls of the cavity. However, all parts of the

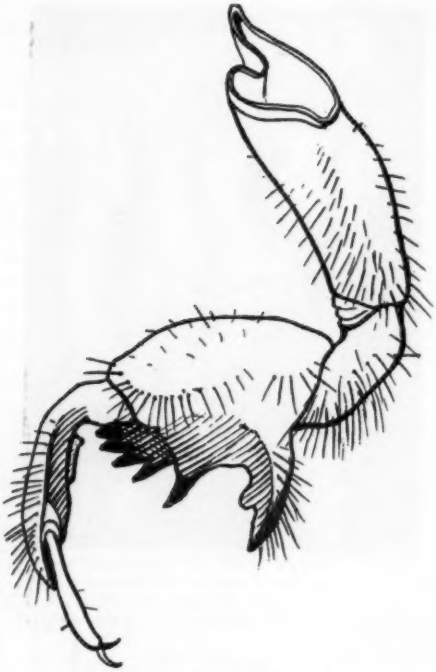


FIG. 3. Snodgrass's sketch of inner face of first right leg, or claw, of cicada pupa. The thickest segment is the femur, the next pointed segment the tibia, and the small final segment the tarsus.

body may come into use, for the hind legs and the abdomen may help shove earth aside and the head may carry earth plastered upon it. In vertical tunnels the animal braces its legs against the sides and, if disturbed, relaxes and drops down.

Finally completed, the last dwelling (Fig. 1) ends above and below in swellings similar to the ends of the preceding feeding dwellings. The lower cavity may be called the chamber and the upper one the dome. The lower chamber is large enough to allow the nymph to turn about and commonly is flattened below, as if to allow the nymph to rest upon a flat surface. Often the chamber slants upward to the shaft, as in Fig. 1, but sometimes the chamber is but the enlarged bottom of the vertical shaft and not turned to one side. The inner linings of both chamber and dome are of the same smoothness as in the shaft. Some measurements of these chambers were: Lengths, 24, 30, 60, 70 mm; widths and heights, 15 or 20 mm. The dome or top of such dwellings comes remarkably near the surface of the earth without breaking through, leaving but a few millimeters of earth till the time for transformation, when the nymph digs its way out. The axis of the dome may be vertical, as in Fig. 4, or horizontal, as in Fig. 6. In the larger nymphs the claws may be stretched out 5 or 6 mm ahead of the animal, which so might receive sensory impressions of obstacles, or of the near surface, and then stop or turn aside; but when it turns aside horizontally, as in Fig. 6, when still 20 mm beneath the surface, it may be the warmth of the surface earth that influences the animal.

Examination of very many tubular dwellings, as well as their plaster casts, shows that, as with many small boring animals, closely neighboring cavities do not interconnect, but each has its own individual upper end and exit and along its course avoids contact with other dwellings though they often run close together. In such shafts as shown in Fig. 5 a common exit might have easily been made. While some unusual dwellings do run horizontally close to the surface, I saw none with the sharp U turn indicated in the picturesque illustration printed by Lander (1894). Yet there were some noteworthy abnormalities; thus in Fig. 7 the lower end of the dwelling is bifurcated; there is a normal chamber on the right and a supernumerary one on the left, as if two cicadas digging upward made two chambers that chanced to meet and were then continued as a single shaft.

A second bifurcation was found in granular red subsoil that had lain some years over topsoil. In this example the more normal chamber was 20 mm long and 15 mm wide and deep and inclined as usual, but the smaller extra chamber was

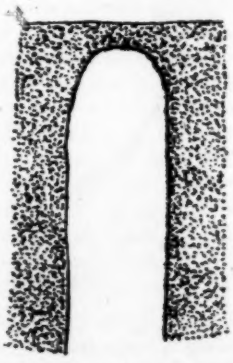


FIG. 4.—Upper end of shaft and dome coming up near to surface of soil. One-half natural size.

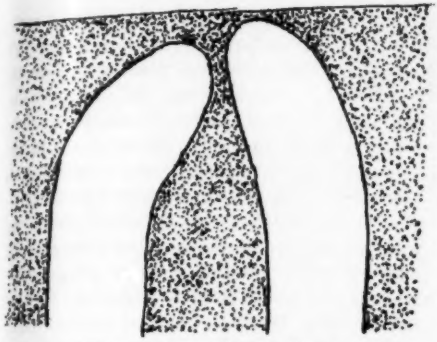


FIG. 5.—Two shafts ending in domes converging as if to have a common exist at surface. One-half natural size.

horizontal, at right angles to the shaft. Both chambers had flat bottoms roughened by particles fallen down the shaft before plaster was poured in.

IMPEDIMENTS TO THE MAKING OF DWELLINGS

In the red clay subsoil a cicada encountered a large slab of partly decayed wood, 30 mm thick, and continued its shaft through it and on up near to the surface. Also, under a privet hedge cicadas coming up under stiff flat dead leaves lying close on the surface continued their shafts through the leaves. Under a copper beech tree we placed obstacles on the surface of the ground: sheets of writing paper, brown paper, and carton pieces. When these lay long in contact with moist earth the cicadas, concealed below, destroyed their domes and dug round holes through the obstacles, even when many sheets were together, though when the obstacle was thick carton with heavy brown-paper surface and thick corrugated interior the cicadas merely bored diagonally in but not through. Having perforated the obstacle, the cicadas deposited pellets and some liquid mud above the surface to form a new dome, as in the sectional view (Fig. 13). Stout paraffin paper lying under a pear tree was riddled with many round holes each surmounted with a thimble of mud.

We observed that under brick walks a few cicadas managed to find a way between bricks to the surface, and under large stones, logs, and planks many came up and then turned off horizontally. It may be many inches before they chance to come to an edge of the obstacle, when they then build upward again on the free surface as a new dome, standing forth into the air, but attached to the face of the obstacle. Under a thin sheet of metal covering about 1 square foot we saw many straight and curved shafts running in all directions, intermingled but each independent of others, some coming shortly to a free edge and others wandering far. Here there seemed no indi-

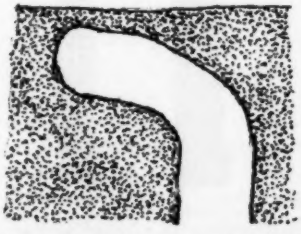


FIG. 6.—A 10-mm shaft turned nearly parallel to surface of earth. One-half natural size.

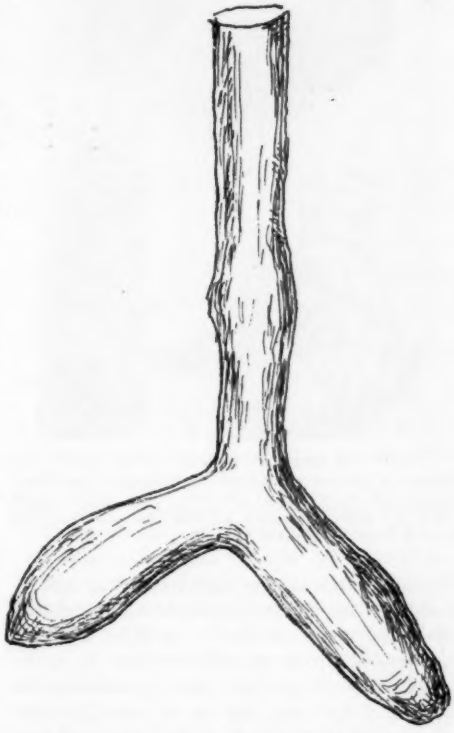


FIG. 7.—Plaster cast of abnormal dwelling with two chambers joined to a single shaft. One-half natural size.

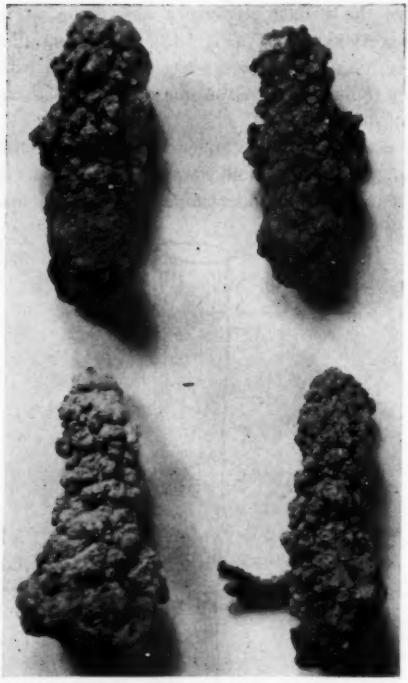


FIG. 8.—Photograph of four aerial structures (upper right of red clay) showing size, surface, form, and closed tops (except lower right, open on other side). One-half natural size. Photograph by Charles H. Weber.

cation that the cicadas found escape except by accident. But in some instances it seemed that the cicadas were guided by sunlight. Under a beehive, 40 by 50 cm, cicadas came up in six shafts, 11 to 85 cm deep, and, encountering the bottom of the hive built on horizontally extensions of the shafts, stuck to and suspended from the hive bottom like the work of termites or certain wasps. Though the hive contacted the earth about most of its edge, the west face was held up by bricks about 25 mm, so that light entered on that side. Three or four of the horizontal structures were aimed more to the west, the others had little length and seemed closed; while the longer ones had opened at the west end. The structure of these suspended mud tubes was that of the mud towers to be described later, with only a very thin mud lining against the roofing wood and the other walls, the mud being brought there and manipulated. A long row of beehives rested upon two parallel joists, 3½ by 1½ inches and 12 feet long, lying in contact with the earth and 10 inches apart and nearly east and west. When these joists were raised, many shafts were revealed, which turned off horizontally along under the joist. Under the northern joist, which was kept quite in the shade by the hives above it, 22 shafts ran from south to north and 19 from north to south, suggesting no guidance.

Under the southerly joist, which early in spring received sunshine before an overhanging apple tree was in leaf, the number going north was 14, south 68—a decided preference for the south direction. As no light entered between joist and earth, we infer the sunlight influenced the cicadas by warming the face of the joist toward which they were thus guided. Temperatures obtained on April 14, 1954, when the joist still lay in place were as follows: At noon along south side of joist in sunshine air read 34°C., along north side, in shade of joist, 28°C. Thermometer bulb under south edge of joist read 29°C. and under north side 28°C. However, late in May, when air was 21° to 24°, the temperature under the joist was 16° to 18°, with no difference between north and south, as leaf shade kept the earth cool.

AERIAL DWELLINGS

Thus the last dwelling of the subterranean nymph is not necessarily restricted to the earth but may be continued up into the air. In fact, aerial extensions may be abundant and of great interest and are well known as turrets, towers, cones, chimneys, huts, and adobe houses. Perhaps the term "spigot holes" may refer to such aerial structures. If so, it is the earliest reference to

FIG. 9.—Vertical section of an aerial dwelling with shaft ending as a dome arched over with applied earth material. One-half natural size.

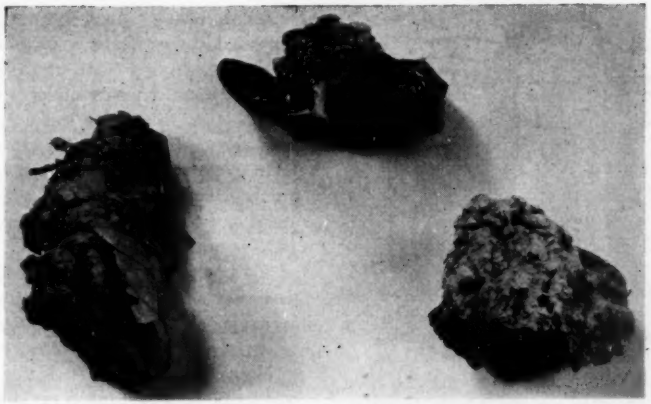


FIG. 10.—Photograph of three aerial structures; lower left, with dead leaves in walls and showing where one was pulled off a hole into lumen of shaft. Lower right, a lump as wide as tall closed as yet at top; upper, a sample of thimble called forth by presence of sheets of paper on surface of earth. One-half natural size.

them; it was used, as quoted by Marlatt (1907), by Thomas Mathews in 1705, writing of a swarm of cicadas in Virginia about the year 1675.

Probably the first illustration of such aerial dwellings was the above mentioned sketch by Lander (1894). Since then good photographs have been published. As shown in Fig. 8, made in Baltimore in 1953, these are large cylinders or cones of mud rough externally as made of pellets stuck together. The material may be topsoil or subsoil or mixtures of both, and some of it seems to have been flowing when applied. Some towers lean over but do not break even when nearly horizontal, which recalls the surmise made by Lander (1894) that the mud material was mingled with some cement supplied by the cicada. Several hundred pellets are seen in one tower, but others are concealed or fused together into larger lumps. These mud houses are durable. Some made late in April 1953 were still recognizable late in January 1954 where protected by dead leaves under privet hedges, despite rain, snow, frost, and thawing.

The walls (Fig. 9) are dense mud, not natural soil, externally more or less made of pellets but internally lined with the same smooth layer found in the underground parts of the dwelling. Rarely small sticks or leaves are incorporated in the walls, and stiff vertical dead leaves may form part of the lining, so that when torn away a hole is opened into the lumen, as in lower left of Fig. 10. When a tower was built up under layers of paper they were cut through and the tower completed above them, leaving the dome sticking up above the paper as in Fig. 11. As seen by comparing Figs. 9, 11, 12, and 13 with 4, the dome of aerial extensions is just like that of subterranean dwellings.

In size these aerial dwellings vary much in any locality, and some localities show an average different from that of some other locality. Thus 159 under separated box trees ranged in height from 15 to 90 mm, in width from 15 to 40 mm; with bores from 9 to 15 mm, thickness of roof of dome from 1 to 5 mm, exit hole from 6 to 15 mm. While under box trees grown as a hedge, 355 ranged in height from 30 to 100 mm, in width from 25 to 35 mm. Again under apple trees the range in height of 136 was from 15 to 100, in width from 10 to 40, with the bores from 7 by 9 to 15 mm.

FUSED AERIAL DWELLINGS

Often shafts are so close together that when extended into the air their walls stick together as one mass with from 2 to 10 separate domes. When but two (Fig. 14) they fuse all along one side only, though in exceptions (Figs. 15 and 16) a pair may lean together and fuse only above or may fuse below and diverge widely above. When several fuse a short dome may be overarched by a taller and so, apparently, the inmate cut off from escape except by digging through the taller neighboring dome. In fact, late in summer one such instance suggested that the inmate had died within unable to escape. However, several others

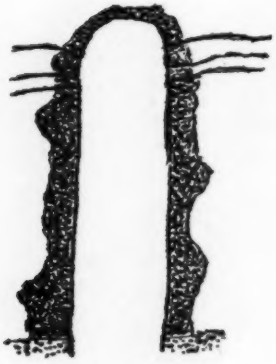


FIG. 11.—Vertical section of an aerial dwelling built up under three layers of paper through which it was continued to end as a dome. One-half natural size.

were found closed with no such cause for failure to escape.

Very rarely was there evidence that cicada nymphs ever made any use of their neighbors' work; in one instance three shafts had but two exits since one inmate had opened its shaft into that of a neighbor. Fig. 14 shows a certain economy of building material resulting from the crowding of neighbors, there being no room for the usual thick wall, only a thin party wall was built between neighbors. Such economy may lead to the observed fact that in some aggregates the entire weight is less than the combined weights of as many separate structures of similar heights.

ESTIMATES OF WORK DONE

Cicadas are muscular animals; even the slow nymphs underground move from place to place, build feeding chambers, suck sap and inject liquid to aid in feeding, and finally construct elongated dwellings that may extend up into the air. This enables one, by weighing the earth deposited, to estimate some of the energy expended in carrying earth upward several inches. Some of these deposits under apple, beech, and English box trees were collected and weighed, with ranges from 4 to 274 grams each. In all, 1,116 of these came from under box trees, 149 in number, covering a sum of areas measured as about one-thirteenth of an acre. They weighed 16,578 grams, or about 28 pounds; i.e., at the rate of 364 pounds per acre. However, a correction is necessary since the dwellings were weighed after air drying all summer, but when originally carried up by the cicadas they were wet. When 20 dry dwellings were dipped in water and drained it was found they had taken up 25 to 35 per cent of their weight. Again 20 were ground to powder and weighed as water was added. When the mass was plastic enough to be made into pellets with the fingers, 39 per cent water had been taken up; with more water the mass lost form and began to flow when 43 per cent had been taken up. So we add at least one-third, or considering that some of the cicadas' material is liquid, as much as 40 per cent to the above dry weights, making thus, roughly, 500 pounds per acre, mined, brought up some inches, and deposited as dwelling walls.

FIG. 12.—Five layers of paper over a concealed shaft were cut through to end as a dome, not yet quite finished late in summer. One-half natural size.

FIG. 13.—Two layers of paper over a concealed dome were cut through to form a dome above those obstacles. One-half natural size.

PLACES AND CONDITIONS IN WHICH AERIAL HOUSES ARE MADE

In this arable soil aerial dwellings appear only in places that were shaded in April, under a building supported on brick pillars; under its eastern eaves shaded by evergreen privet; under the wooden steps of east and west ends of elevated wooden porch; but not under the porch itself where abundant in 1936 when adjacent bushes had not been removed; under English ivy covering the ground; under dense growth of dead nettle (*Lamium purpurem* L.), under north face

of privet hedge, and under its south face where dead leaves had collected; under evergreen cane and bamboo; under apple, beech, and English box trees. Also in the following peculiar conditions: under a board 16 inches wide and 19 feet long, supported at the ends 27 inches above the earth, surrounded by apple trees showing no aerial structures at all. In this faint shade, especially near its northerly edge, many fine dwellings were built up. When we moved this board 2 feet to the north, many soft new towers arose in the new shade.

The making of aerial dwellings by providing artificial shade was evoked as follows: Early in April a large zinc tub was overturned under one of the above apple trees known to have many subterranean dwellings under it and at length, April 29, a tower 2 inches in height arose under the

FIG. 14.—Cross section of two narrow shafts of aerial dwellings that coalesced with only a thin party-wall between. One-half natural size.

tub the night previous. This bent over nearly horizontally, and by May 3 the inmate had removed the old dome and added pellets making a new dome.[1] In a henyard, where there were only concealed dwellings, scraping the surface revealed 36 shafts thus opened, May 6; these were covered over with a large zinc tub making a dark space within which the next morning 30 soft dwellings had been built into the air, but outside the tub there were none. In the same region a number of chimneys arose from a square foot of hard earth when covered with a wooden trough. The previously described structures (p. 24), under joists, etc., are essentially aerial towers

[1] Whether in light or darkness each aerial dwelling is closed above, and if the old dome is removed a new one is made at once. Thus under dense lamium shade removal of domes was followed the next night by the making of new ones in most all the dark cavities formed by placing small tin cans, 4 by 2 inches, over the opened shafts. And under apple trees where the earth was very wet removal of 40 towers to reveal open shafts resulted the next morning, May 3, in the appearance of nearly as many new structures made within such cans and 3-inch flowerpots.

FIG. 15.—Two aerial dwellings leaning together and coalescing above. Both closed above. Lining indicated by broken lines. One-half natural size.

built in the dark and forced into horizontal postures.

HOW ARE AERIAL DWELLINGS MADE?

The aerial dwellings are built up rapidly in the night when no one has observed how, but we assume that they are made much as are the former feeding chambers, for knowledge of which we rely on the above-mentioned observations of Marlatt and Snodgrass. To this we add the following: In 1902 we saw cicadas, placed in tubes

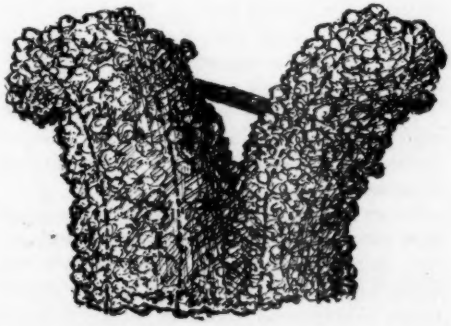


FIG. 16.—Aerial dwellings of a larger and a smaller variety built close together and then diverging widely. The large on the left is open at top. A small stick was built into both where diverging One-half natural size.

of loose earth, place mud onto the right and the left sides of the face and so carried it up to make pellets; also some huts found late in summer, 1953, with partly finished still-open domes suggest how domes are made in the air. Each (Fig. 12) had across its summit an open slit about 10 by 5 and 6 mm with very thin edges, not more than 0.5 mm. As yet no pellets had been placed over the top of the dome. We imagine the claws would reach out of the slit to apply mud, that the slender tarsus would be used in troweling the mud, and that water was supplied by the cicada nymph.

CONCLUSION

The last dwellings of seventeen-year cicadas are of interest as showing what insects can do with tools; as examples in the comparative architecture of dwellings of small animals; as a means for estimating some of the energy expended; and as beneficial factors in the life of these plant parasites. Also it is noteworthy that in the roofs of these last subterranean dwellings only a thin layer of earth remains to be perforated for egress into the air above; and that this advantage is persistently maintained under the diverse conditions we have described and illustrated.

When over 60 or more acres of woodland the earth is riddled with borings such as indicated in Fig. 2, the effects must be considerable, for these holes remain open for a year or more admitting air and surplus rain and serving for roots and for many insects, spiders, and other small forest creatures. Again, when towers of mud weighing perhaps 500 pounds per acre are deposited, ultimately to be disintegrated on the surface, thus "plowing" the earth after the manner of earthworms, there seems compensation for the injury done in sucking root sap and injury to twigs.

Why at some times and places the last dwellings are extended as aerial structures, huts, or towers is a question needing solution through experimentation.

It has been thought that these aerial dwellings were due to water, to peculiar soil, or to temperature. But in Baltimore the earth was no wetter where towers appeared than in nearby regions where subterranean dwellings sufficed—except only one place where surface water under an apple tree made a wet basis for towers, but here there was also shade in April, and this as well as wetness may have acted by lowering the earth temperatures below that within the towers up in the warm air. Cicadas are parasites upon plants, drinking sap not only when young nymphs but when adults. That the oldest nymphs near the surface also drink sap is inferred but not demonstrated. That they are not necessarily restricted to sap for needed water is shown by the following experiment: Nymphs dug from their concealed shafts near the surface were kept some days in dry earth, each in a hole simulating a shaft, and then put onto garden earth. They at once thrust their beaks deep into the earth and, as if thirsty, stood long in the drinking attitude assumed by adults sucking sap from trees. Apparently they sucked moisture from the earth. Though they had been kept in darkness they had not erected aerial dwellings, nor had most of them even made domes over the holes they were in, presumably lacking sufficient water for such work. That liquid from the earth may be used by old nymphs for their building needs is implied in their long life near the surface when the earth is moist and there may be no roots to suck, as in the instance described above where they lived in granular red clay subsoil free from roots. It seems probable much of the liquid needed for mud making and even for self maintenance is derived from the earth.

With water constituting a third or more of the aerial dwellings, it is evident wet soil is needed for such work. As part of these aerial structures seems to be liquid mud and as we do not know how cicadas can carry liquid mud, we assume that they made the earth liquid when they used it. All through cicada life liquid is freely drunk and freely expelled, since, as described by Myers (1928), the cicada has a remarkable filtering apparatus that lets liquid pass rapidly out. Hence, whenever cicadas have liquid to drink they have it to expel.

When the actual process of hut-building is observed we anticipate it will be seen that the cicada uses both ends of its body, somewhat as we observed (1911) certain termites do when building in Jamaica.

Temperature has much to do with emergence, as shown when pipes heated the earth and cicadas emerged a year in advance. Hopkins (1898) observed in West Virginia that emergence was earlier where warmth was greater, either from lower altitude or from a more southern location.

Krumbach (1917) kept detailed records of temperatures in part of a botanical garden in Austria-Hungary, watched 27 cicadas emerge during 27 days, and also noted they emerged later in the shade of a wall. He was of the opinion that temperature was the important factor in bringing them forth. During the period of emergence temperatures were as follows: a meter above ground 11.2° to 19.2° minimum and 31.6° to 35° maximum; at the surface 10.8° to 16.2° minimum; down in the earth 300 mm 25.3° to 26.6°; down 600 mm 21.4° to 26.2°; down 1 meter 19.7° to 25.1°C.

Applying the above to our cicadas it may be that they were influenced by temperature gradients in coming up toward the surface and by surface temperature in emergence; also that a cicada in a tower might well be warmer than one beneath the surface. Lander (1894) studied cicadas near Nyack, N. Y., and concluded that the chimneys were built as places to cool off in, for he argued the very warm spring had unduly heated the trap rock, smoothed by glaciers, underlying the thin soil. But as no thermometer readings are given we are free to assume that the thin clay soil would not drain well into the glaciated rock but would hold the melted winter snow and be cold from evaporation, whereas cicadas up in towers would be warmed by the sunshine of an exceptionally warm spring.

That cicadas may get higher temperatures up in towers than down below is indicated by some experiments made in February and March 1954 at one of the spots in which chimneys had arisen in April 1953, which showed that a thermometer placed in a dry chimney over a hole resembling a cicada shaft registered 4° or 5° higher than down 1 to 7 inches in the earth, but only 1° lower than the warmer air. Thus on March 29, 1954, when the surface temperature of the earth was 28° in full sunshine, the temperature of the air was 19°, within the chimney 18°, at the surface 13°, down 12 inches 12°C.: in the shade of the same evergreen privet in which chimneys were made in 1953. This makes credible the view that in 1953 cicadas there found temperatures in their chimneys higher than below ground and comparable with that of the surface in full sunshine.

Moreover, as described above (p. 23), cicadas meeting certain obstacles continued their shafts horizontally as modified chimneys to the limit of the obstacle and then upward again to end with a normal dome. Temperature taken there a year later showed that the sunshine warmed one face of the obstacle and that the cicadas, in the dark, in a majority of instances, built toward the higher temperature.

We advance the hypothesis that the chief factor in inducing the cicada to extend its last dwelling into the air is temperature; in the shade or under other conditions when the surface earth is not warm enough, a higher temperature is attained up in turrets surrounded with warm air.

Though most of the cicada's life with its growth and shedding is spent down in lower temperatures, we assume that higher temperatures are attained and probably needed for the final perfection of internal organs not needed in previous subterranean life. To test this hypothesis, temperatures might be obtained in air, on the surface, and beneath the ground over an area where cicadas are expected to issue soon. Such data might well indicate where aerial dwellings would arise and where only subterranean dwellings would be found.

LITERATURE CITED

ANDREWS, E. A. *Observations on termites in Jamaica.* Journ. Animal Behavior **1**: 193–228. 1911.

———. *Periodical cicadas in Baltimore, Md.* Sci. Monthly **12**: 310–320. 1921.

———. *The seventeen year cicada, alias locust.* Quart. Rev. Biol. **12**: 271–293. 1937.

HOPKINS, A. D. *The periodical cicada in West Virginia.* West Virginia Agr. Exp. Sta. Bull. 50: 46 pp., 23 figs., 1 map, 4 pls. 1898.

KRUMBACH, T. *Zur Naturgeschichte der Singcicaden im Roten Istrien.* Zool. Anz. **48**: 241–250. 1917.

LANDER, B. *Hut-building seventeen-year cicadas.* Sci. American **71**: 233–234. 1894.

MARLATT, C. L. *The periodical cicada.* U. S. Dept. Agr., Bur. Entomology, Bull. 71: 181 pp. 1907.

MATTHEWS, THOMAS. *Swarms of cicadas as one of the three prodigies appearing in Virginia about 1675.* (Quoted in "A Library of American Literature," ed. by E. C. Stedman and E. M. Hutchinson, vol. 1: 462–463. 1887.)

MYERS, J. G. *The morphology of the Cicadidae (Homoptera).* Proc. Zool. Soc. London, 1928: 365–472, 75 figs.

POTTER, N. *Notes on the* Locusta septentrionalis americanae decem septima: 27 pp., 1 pl. Baltimore, 1839.

SNODGRASS, R. E. *The seventeen-year locust.* Ann. Rep. Smithsonian Institution for 1919: 381–409, illus. 1921.

ICHTHYOLOGY.—*Flatfishes of the genus* Symphurus *from the U.S.S.* Albatross *Expedition to the Philippines, 1907–1910.* PAUL CHABANAUD. (Translated by Mme. Patricia Isham.) (Communicated by Leonard P. Schultz.)

Max Weber and L. F. de Beaufort,[1] who published the most recent summary of the fish fauna of the Indo-Australian Archipelago, mention only three species in the genus *Symphurus*: *S. regani* Weber and de Beaufort, *S. gilesi* (Alcock), and *S. microrhynchus* Weber and de Beaufort. An additional species, *S. marmoratus* Fowler, was described from Jolo Island, Philippines. No less than six species are represented among the 139 *Symphurus* specimens captured between April 10, 1908, and December 16, 1909, in that archipelago or its immediate environs between lat. 20° 37′ N., long. 115° 43′ E, and lat. 5° 24′ S., long. 122° 18′ 15″ E., by the U. S. Bureau of Fisheries steamer *Albatross* in the course of its successive cruises, which, altogether, constituted the *Albatross* Expedition to the Philippines (1907–1910). I cannot thank too warmly Dr. Leonard P. Schultz, Curator, Division of Fishes, U. S. National Museum, for his favor in trusting to me the study of this material of exceptional scientific value and interest. Also I thank Mme. Patricia Isham for translating this paper.

Among the three species captured by the *Siboga* in 1899–1900, and mentioned or described by Weber and de Beaufort, only *Symphurus regani* was found again by the *Albatross*. However, the investigations of the latter ship augmented the fauna of the Indo-Australian Archipelago by three species, *S. woodmasoni* (Alcock), *S. septemstriatus* (Alcock), and *S. strictus* Gilbert, that are more or less widely scattered in the tropical Indo-Pacific complex, and by two new species, *S. schultzi* and *S. luzonensis*, which are described in the lines that follow.

In reality, *S. woodmasoni* was captured by the *Siboga* in the Banda Sea; but the unique specimen is mentioned by Weber, without determination (*Siboga*, Fishes, 1913: 445, No. 4).

The following abbreviations are used: A, anal fin; C, caudal fin; D, dorsal fin (also the letter D indicates dissection); Mx, Maxillary; R precedes the meristic formula determined from radiography; S, number of scales, counted between the vertical of the opercular opening and the base of the caudal fin; V, pelvic fin; n, blind side; z, eyed side.

The position of the caudal extremity of the maxillary (Mx) on the eyed side is indicated in the following fashion: I, in front of the vertical of the anterior border of the fixed eye; II, underneath the anterior half of the fixed eye; III, underneath the posterior half of the fixed eye; IV, in back of the fixed eye. The intermediary positions are indicated I/II, II/III, and III/IV.

The same symbols determine the position of the first dorsal ray (D 1), in relation to the movable eye.

The formula for number of vertebrae conforms with the example: *a* 9 [3 + 6] + *c* 44 = *t* 53. The letter *a* means number of abdominal vertebrae. The letter *c* means number of caudal vertebrae. The letter *t* indicates the total of the preceding numbers. The numbers put between brackets [3 + 6] analyze the composition of the abdominal vertebrae. The first number (3) is that of the vertebrae deprived of the hemal arch; the second (6) that of the vertebrae that possess that arch. In all the *Symphurus*, except individual abnormalities not yet found, all the abdominal hemal arches are closed by distal coössification of the two hemitoxes[2].

Symphurus woodmasoni (Alcock, 1889)

D 91–99. A 78–86. C 14. V 4. S 80–90 (+?). Mx: II–III (III/IV[3]). D 1: II–III (III/IV[3]). In hundredths of the standard length: head 20–25; height 23–26 (27–29). In hundredths of the length of the head: eye 12–14(15); space between the eyes 0; C 52–76 (90–115[4]). In hundredths of the body height: height of D or of A 36–45. In alcohol the eyed side is of bright reddish

[1] *The fishes of the Indo-Australian Archipelago* 5: 208–211. 1929.

[2] Cf. Chabanaud, *Morphologie comparée des arcs hémaux abdominaux des téléostéens symétriques et dyssymétriques*. C. R. Acad. Sci. 233: 1393, eff. 5. 1951.

[3] Only one case.

[4] When its length does not attain about 60 percent of that of the head, the caudal fin can be considered deteriorated.

brown, generally even, but often enough varied with dark brown marblelike veins. The fins are brown, more or less dark, but becoming lighter from front to back, so the caudal fin is often colorless. The blind side is colorless and the reddish tint of the musculature is readily visible. The peritoneum is generally black.

Number of specimens studied: 85. Standard length (largest observed): ♂103 mm; ♀121 mm. Sex ratio (82 observations): ♂28; ♀54. Vertebrae (6 observations): 50–52, 9 of which [3 + 6] abdominal.

Record of specimens for *Albatross* dredging stations[5]: U.S.N.M. 138049, station 5247, 2 specimens; U.S.N.M. 138058, station 5402, 1 specimen; U.S.N.M. 138062, station 5403, 7 specimens; U.S.N.M. 138034, station 5404, 1 specimen; U.S.N.M. 138035, station 5405, 2 specimens; U.S.N.M. 138036, station 5409, 1 specimen; U.S.N.M. 138038, station 5412, 1 specimen; U.S.N.M. 138039, station 5418, 1 specimen; U.S.N.M. 138059, station 5501, 13 specimens; U.S.N.M. 138060, station 5502, 27 specimens; U.S.N.M. 138061, station 5503, 22 specimens; U.S.N.M. 138041, station 5508, 1 specimen; U.S.N.M. 138021, station 5516, 1 specimen; U.S.N.M. 138048, station 5537, 1 specimen; U.S.N.M. 138047, station 5538, 1 specimen; U.S.N.M. 138051, station 5623, 1 specimen; U.S.N.M. 138052, station 5626, 1 specimen; U.S.N.M. 138056, 1 specimen from Philippines without locality.

Symphurus schultzi, n. sp.

D 85–87: A 72–75. C 14. V 4. S ± 70–80. Mx II. D 1: II/III–III/IV. In hundredths of the standard length: head 21–25; height 24–30. In hundredths of the head length: eyes 17–19; interorbital space 0; C 50–62. In hundredths of the body height: height of D 42–47. In alcohol: The eyed side is an even reddish brown, now light, now dark; the fins are more or less brown or blackish, progressively lighter from front to back. The blind side is pale or pigmented. The peritoneum is black. On two dissected specimens, U.S.N.M. 138046 and 138057 the vertebrae number 48 of which *a* 9 [3 + 6] are abdominal.

Named in honor of Dr. Leonard P. Schultz, curator of fishes, United States National Museum, *S. schultzi* differs from *S. woodmasoni* in the fewer rays, D (85–87, instead of 91–99); A (72–75 instead of 78–86), and by its eyes that appear a little larger (17–19 hundredths of the head length instead of 12–15), also in fewer vertebrae (48 instead of 50–52), the formula of the abdominal vertebrae is the same 9 [3 + 6].

This species is described from 5 specimens, 2 ♂ and 3 ♀; maximum standard length ♂ 70 mm., ♀ 64 mm.

Record of specimens for *Albatross* dredging stations: U.S.N.M. 138044, holotype; ♀, station 5508. Paratypes: U.S.N.M. 138025, Station 5201; U.S.N.M. 138033, Station 5373; U.S.N.M. 138057, St. 5506; U.S.N.M. 138046, Station 5536.

Symphurus septemstriatus (Alcock, 1891)

D 93–101. A 81–89. C 12. V 4. S 96–100. Mx, (I/II[6]) II–III. D 1: II–II/III (III[6]). In hundredths of the standard length: head 18–22; height 21–27. In hundredths of the length of the head: eye (12) 14–18 (19); interorbital space 0; C 60–86. In hundredths of the body height: height of D or of A 36–41. In alcohol, the eyed side is of reddish brown, more or less clear with nebulous dark brown areas, arranged in transverse bands; rarely indistinct, and numbering about 7 to 12, between the operculum and the base of C; fins brownish, pale towards the rear. The blind side is usually reddish brown, lighter than the eyed side, but always of uniform color. Peritoneum is black.

Specimens studied numbered 38; maximum standard length ♂ 78 mm. ♀ 77 mm. Sex ratio for 33 observations: ♂ 21, ♀ 12. Vertebrae (4 observations): *a* 9 [3 + 6] + *c* 44 = *t* 53 (3 individuals), *a* 9 [3 + 6] + *c* 45 = *t* 54 (1 individual).

Record of specimens for *Albatross* dredging stations: U.S.N.M. 138026, station 5216, 4 specimens; U.S.N.M. 138023, station 5265, 2 specimens, U.S.N.M. 138043, station 5268, 2 specimens; U.S.N.M. 138028, station 5298, 1 specimen; U.S.N.M. 138029, station 5301, 1 specimen; U.S.N.M. station 138040, station 5326, 2 specimens; U.S.N.M. 138042, station 5387, 16 specimens; U.S.N.M. 138041, station 5388, 1 specimen; U.S.N.M. 138031, station 5391, 1 specimen; U.S.N.M. 138032, station 5392, 2 specimens; U.S.N.M. 138035, station 5405, 1 specimen; U.S.N.M. 138037, station 5411, 1 specimen; U.S.N.M. 138038, station 5412, 1 specimen; U.S.N.M. 138060, station 5502, 1 specimen; U.S.N.M. 138044, station 5508, 1 specimen.

[5] *Albatross* dredging station records were published in: Rept. Comm. Fish., 1910 (741): 1–97. Nov. 29, 1910.

[6] Only one case.

Symphurus regani Weber and Beaufort, 1929

D 103–104. A 89–92. C 14. V 4. S ± 100. Mx III. D 1: I–II. In hundredths of the standard length: head 17; height 24–26. In hundredths of the length of the head: eye 15; interorbital space 0; caudal fin ± 73. In hundredths of the body height: height of D or of A: ± 30. In alcohol, the eyed side is of an even reddish brown, not dark, the fins dark brown. The blind side is colorless or whitish.

Record of specimens for *Albatross* dredging stations: U.S.N.M. 138045, station 5526, 1 ♂ specimen, 112 mm standard length, R:*a* 10 [3 + 7] + *c* 47 = *t* 57; U.S.N.M. 138053, station 5646, 1 ♂ specimen, 122 mm, R:*a* 10 [3 + 7] + *c* 47 = *t* 57; U.S.N.M. 138054, station 5647, 1 ♀ specimen, 96 mm. R:*a* 10 [3 + 7] + *c* 47 = *t* 57.

Symphurus luzonensis, n. sp.

Holotype ♂. Total length 80 mm. Standard length 72 mm. Length of the head 13 mm. D 99. A 84. C 12. V 4. S 104. Mx II. D 1:II/III. In hundredths of the standard length: head 18; height 23. In hundredths of the length of the head: eye 14; interorbital space 0; C 61. In hundredths of the body height, height of D or of A 38. In alcohol, the eyed side is of a light reddish brown; fins pale; blind side colorless. U.S.N.M. 138043, holotype from Station 5268, ♂ specimen, R:*a* 10 [4 + 6] + c 42 ≂ *t* 52.

Captured near the island of Luzon, the holotype of *Symphurus luzonensis* differs from *S. regani* in the fewer rays of its three median fins, notably of C (12 instead of 14); also by its caudal vertebrae (42 instead of 46 or 47), the formula for abdominal vertebrae are the same, *a* 10 [4 + 6], proof of the close affinity existing between these two species.

Symphurus strictus Gilbert, 1905

D 116–121. A 101–106. C (13) 14. V (3) 4.[7] S 130–140. Mx II–III. D 1:I–II. In hundredths of the standard length: head 15–18; height 21–24 (27). In hundredths of the length of the head: eye 11–14; interorbital space 0; C ? In hundredths of the body height: height of D or of A 33. In alcohol the eyed side is evenly bright red, with the fins brownish grey, becoming lighter from front to back. The peritoneum is black. Blind side same color as eyed side, but a little lighter.

Seven specimens studied, 4 ♂ and 3 ♀. Standard length (maxima observed): ♂ 126 mm; ♀ 86 mm.

Record of specimens for *Albatross* dredging stations: U.S.N.M. 138024, station 5269, 1 ♂ specimen; U.S.N.M. 138027, station 5290, 1 ♂ specimen, R:*a* 9 [3 + 6] + *c* 52 = *t* 61; U.S.N.M. 138030, station 5294, 1 ♀ specimen; U.S.N.M. 138022, station 5589, 1 ♂, R:*a* 9 [3 + 6] + *c* 52 = *t* 61; U.S.N.M. 138050, station 5621, 1 ♀ specimen; U.S.N.M. 152779, station 5623, 1 ♀ specimen; U.S.N.M. 138055, station 5645, 1 ♂ specimen.

[7] C 13, for U.S.N.M. 138024. V 3, for U.S.N.M. 138050.

MALACOLOGY.—Conus eldredi, *new name for one of the poison cones.* J. P. E. Morrison, U. S. National Museum.

The subgenus *Gastridium* Modeer (Svenska Vet.-Akad. Handl. (n. s.) 14: 196. 1793) includes a few relatively large but thin-shelled species of the genus *Conus*. It is probable that these species are more active and much more rapid in growth of shell than the great majority of cone species. One species somewhat smaller than the genotype of *Gastridium* (*Conus geographus* Linnaeus) but most closely related to it, and therefore to be handled with equal caution against its poison bite, is without a valid scientific name.

The earliest name *Conus geographus rosea* Sowerby (Conch. Illus., pt. 32: fig. 33. 1833) was twice preoccupied by *C. roseus* Fischer, 1807, and Lamarck, 1810. The next name given, *Conus intermedius* Reeve (Conch. Icon.: pl. 23, fig. 129. 1843) is preoccupied by the name *C. intermedius* Lamarck, 1810. Likewise the third name *Conus mappa* Crosse (Rev. Mag. Zool. (2d ser.) 10: 200, 205. 1858), given as a nomen novum for *intermedius* Reeve, is preoccupied by the name *Conus mappa* Solander (in Humphrey, Portland Catalogue: 116, No. 2554. 1786). This poison cone is here given the new name *Conus* (*Gastridium*) *eldredi*, in honor of my brother Lt. Cmdr. R. Ray Eldred Morrison (U.S.N.R.), who collected the species at Abamama in the Gilbert Islands in 1944. This new name may commemorate in a small way the considerable contributions to the knowledge of mollusks made by interested members of the United States Armed Forces (both regular and reserve) during World War II.

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